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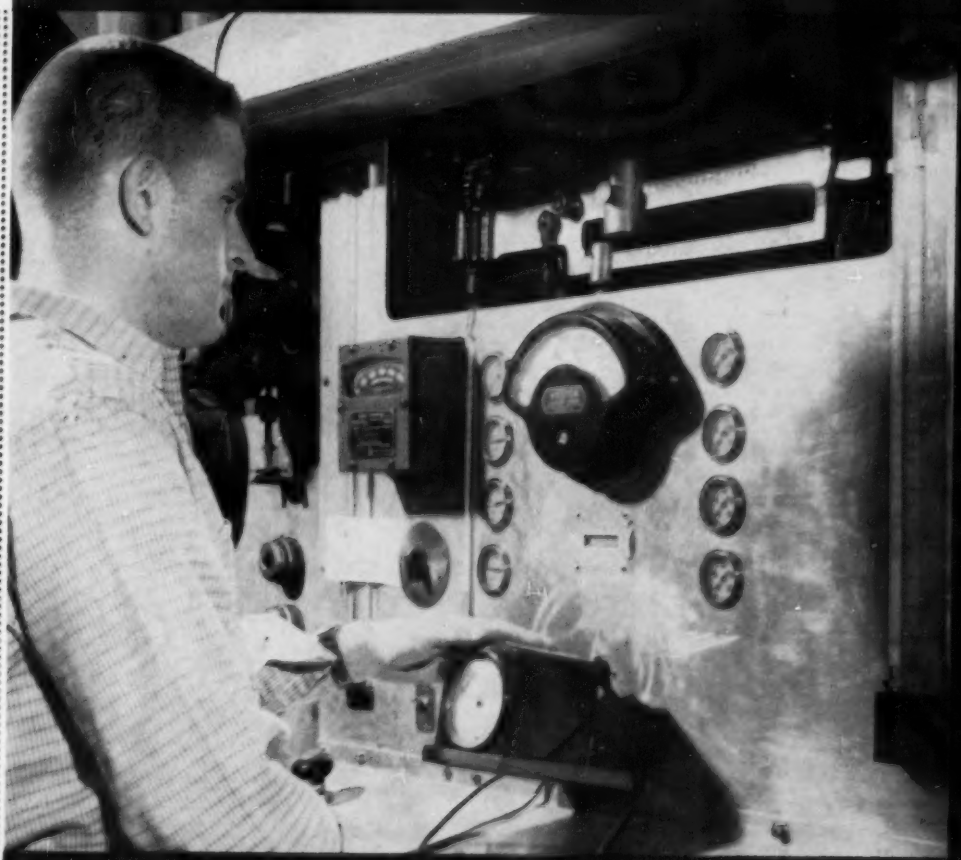

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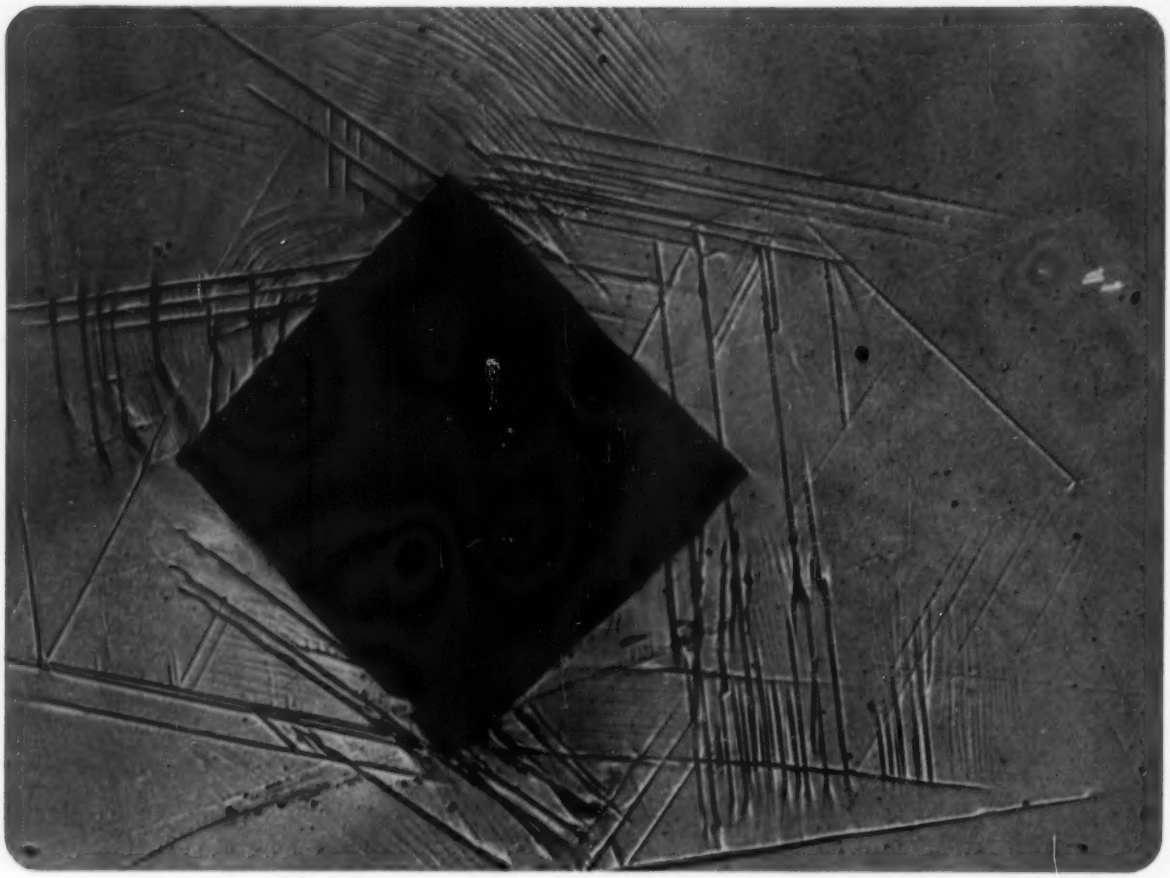

Did you ever hear atoms move?

The physicist positions a single crystal of age-hardened steel under the sharp diamond penetrator. He touches a pedal, and the pyramidal tip of the diamond squeezes into the polished surface of the steel.

The instant that it touches, things begin to happen inside the crystal. Atoms begin to slip and slide, in layers. Some layers abruptly wrinkle and corrugate. If you listen hard when this happens, you hear a faint, sharp, "click." This is the sound of atoms suddenly shifting within the crystal.

You can see the action, too—or, rather, the results of it. The photomicrograph above shows the characteristic ridges and ripples. The black diamond in the center is the depression made by the penetrator.

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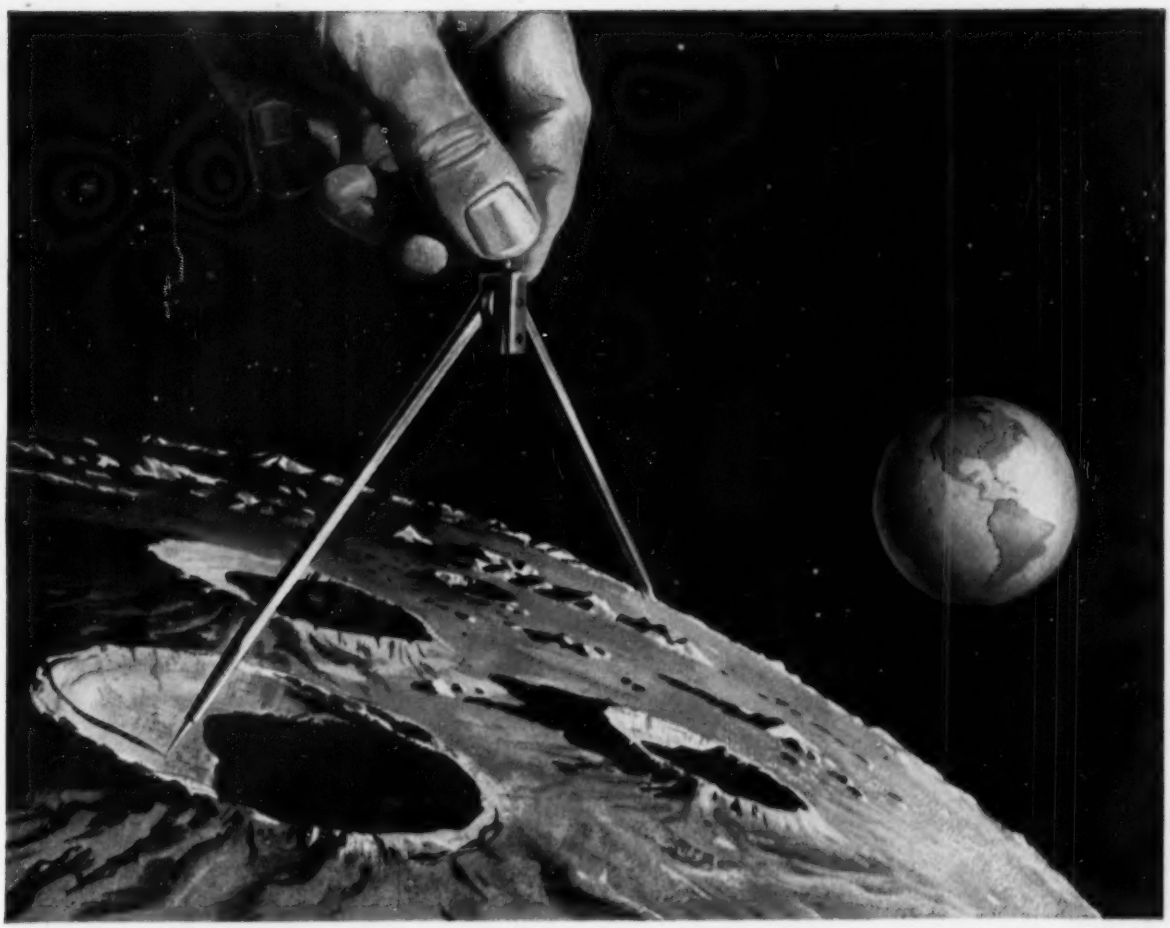

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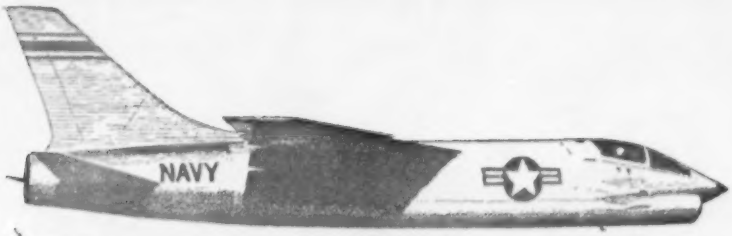

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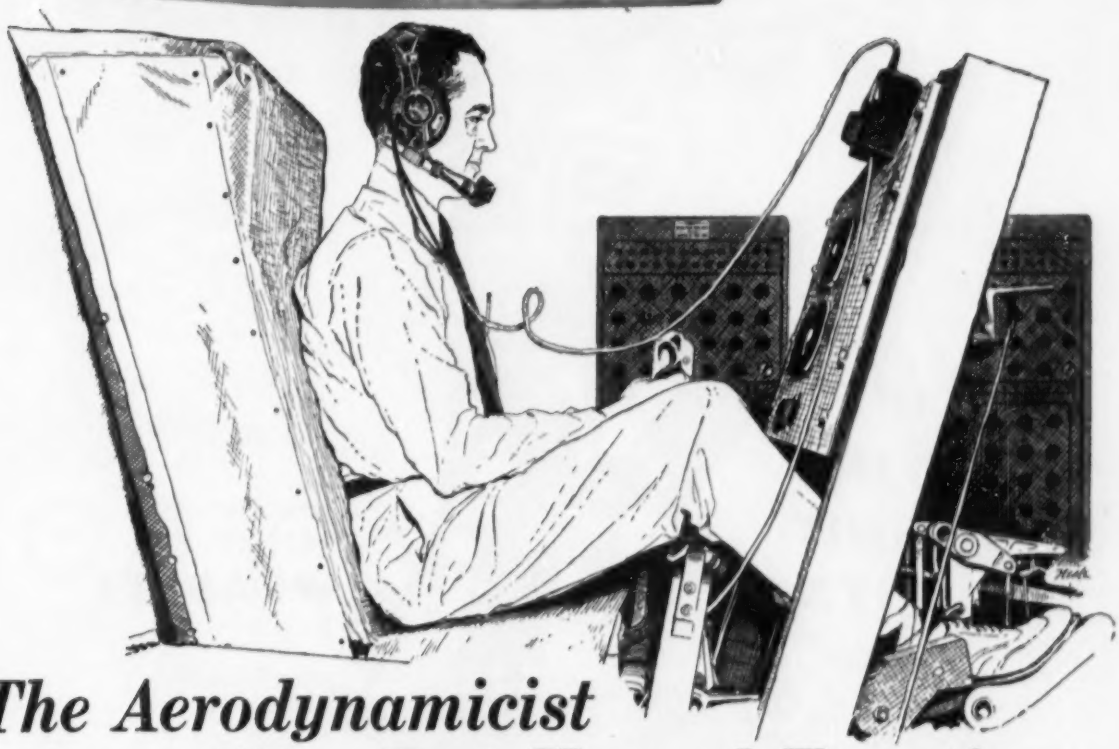

The Aerodynamicist Who Test-Hopped Equations

There'd never been a fighter that could barrel at more than 1,000 mph one minute and land on a carrier the next. And, as a result, there was unusually keen advance interest in the flying qualities of the airplane proposed by Chance Vought.

Jim Madden was more than curious. As an aerodynamic design specialist, he would help develop the Crusader's handling qualities. His job began with wind tunnel tests.

Jim converted tunnel information into a graphic picture of static and dynamic forces affecting Crusader stability. He used analog computers and equations of motion to predict the build-up of forces during maneuvers. Hinge moments, loads, and required rates of control motion were determined and released to Servomechanism and Product Design groups. Soon the Crusader's stabilization and power control packages began to take shape.

Jim's part in the project could have ended right there. But Vought's control system simulator helped him proceed to some thoroughgoing conclusions.

It duplicated the complete rod system and all servomechanisms that would control the speedy new fighter. In the simulator's cockpit, high above the Structures Lab floor, Jim previewed control responses that test pilots later would experience. Airplane responses to Jim's rudder kicks and aileron movements were recorded on analog computers. Any inability of the control system to position the aircraft during flight was easier to spot . . . and, with test and design engineers on hand . . . easier to correct.

"It was like a big schematic — only better," says Jim of the simulator.

"It gave me a chance to work with the whole system.

"And actually watching aircraft responses to the controls gave me a feeling for how fast they happen."

Another thing that moved fast was Crusader development. Vought's simulator and other facilities detected problems before they compounded. The fighter reached operational readiness in record time.

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COVER: A Mechanical Engineering student tries hard to make the data come out right.

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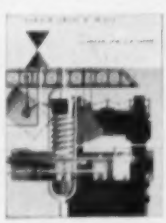

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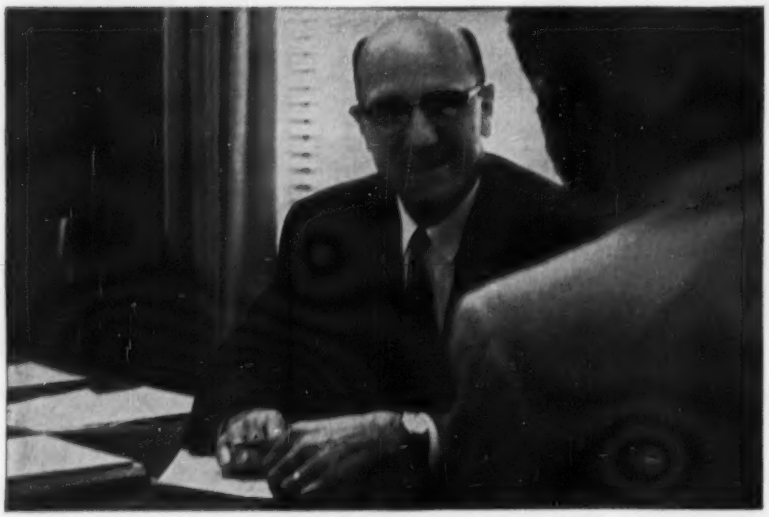

KARL BAUSCH, *Chief Electrical Engineer, Power Division of the Bechtel Corporation.*

ELECTRICAL ENGINEERING

One of a series of interviews in which Bechtel Corporation executives discuss career opportunities for college men.

QUESTION: *Mr. Bausch, in considering a position with Bechtel, or any other firm, isn't it true that what most college men want to know first of all is "What will I be doing?"*

BAUSCH: That's true, and it isn't an easy question to answer. So much depends on individual preferences and abilities and the way a man develops. On joining us, he would be asked if he'd like to work on the drafting board doing layout work. As an alternate, he might prefer a starting assignment involving helping out on calculations, requisitioning materials, writing specifications, etc.

QUESTION: *In other words you try to give the new man some freedom of choice?*

BAUSCH: As far as possible. We know that the beginning period is a difficult one. It takes some time for him to get his feet on the ground and we try to "expose" him to many different activities. In that way he gets needed experience and familiarity that help him decide the work for which he feels best qualified. It also gives us the opportunity to evaluate his potential.

QUESTION: *Assuming a man shows the necessary ability and begins to produce, how does he branch out?*

BAUSCH: Generally, in either of two ways. He may work on the electrical portion of power plants, designing circuits, control and relaying systems, unit protection, etc. The other way is on the physical layout of power plants —that is, location of equipment, conduit and raceway systems, etc. In either case he would be put in charge of one section of the project.

QUESTION: *And his next advance would be...?*

BAUSCH: Assuming he progresses satisfactorily, he would ultimately move into a lead job as a group supervisor in charge of the design of the electrical system of the complete plant.

QUESTION: *Could you give an estimate of the time involved in the various steps?*

BAUSCH: That's impossible. We have no hard and fast schedule. In general, we have found that it takes a man about a year to get his feet on the ground and become a real producer. From that point on, it's up to him.

QUESTION: *In other words, he can advance in keeping with his individual ability?*

BAUSCH: That's right. Of course, there are many other factors involved, including the vitally important one of the great advancements being made in every phase of the electrical industry. These create new jobs and new types of jobs involving new skills. And for every opportunity existing today, it is safe to predict there will be at least two tomorrow.

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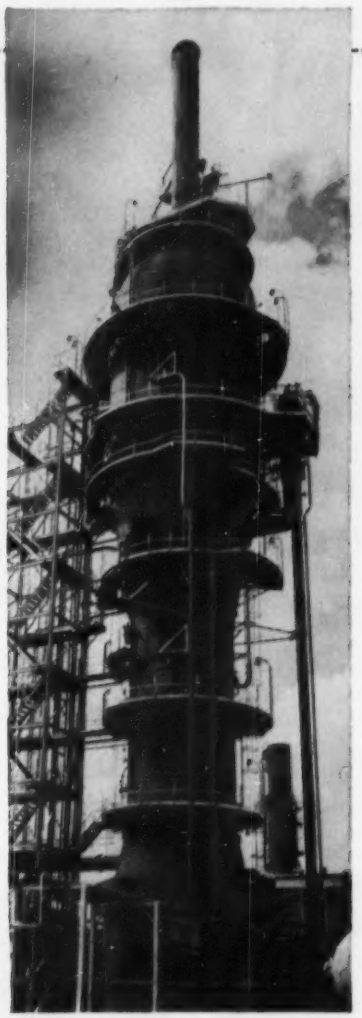

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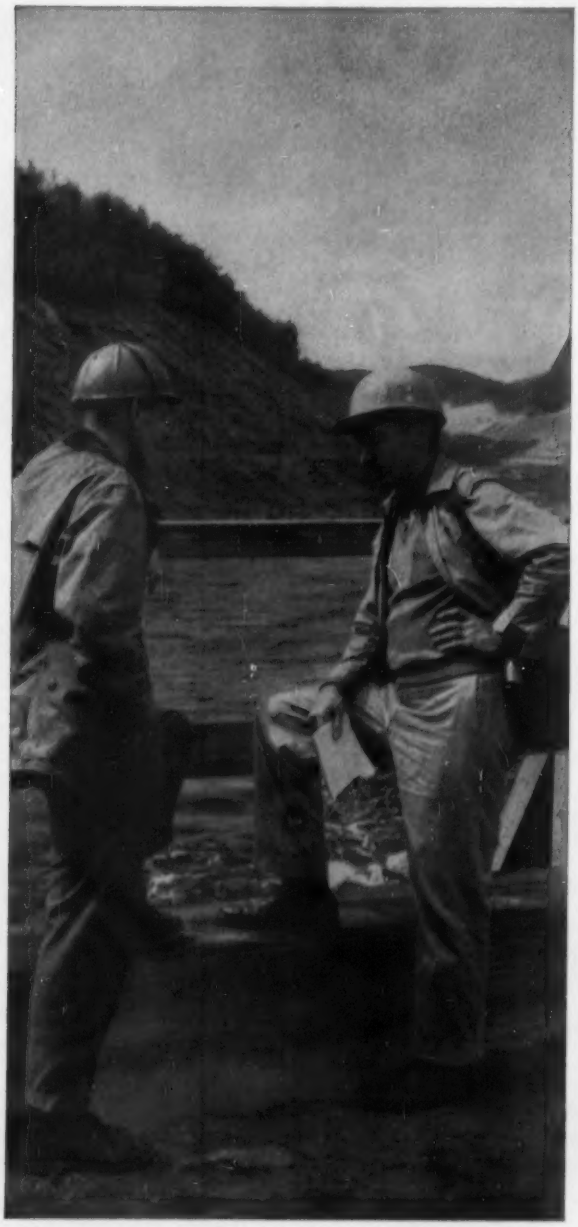
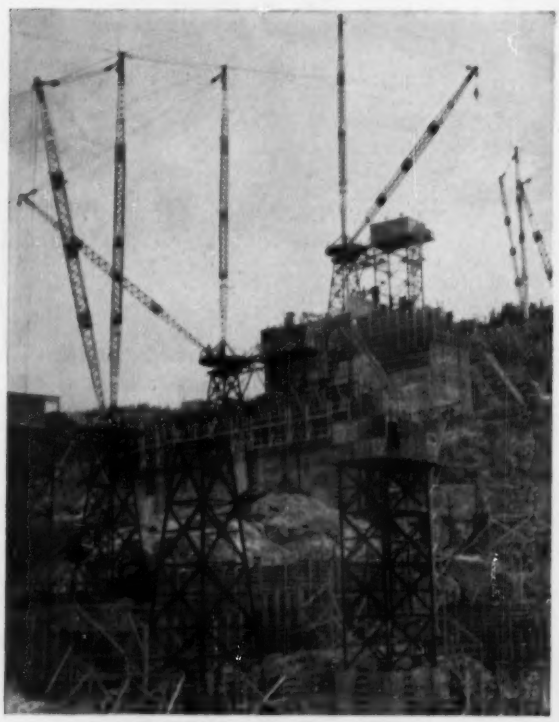


An Editor with a Hard Hat. Art, pictured above at right with Assistant Resident Engineer McCormack, observes progress at the Beaumont Rapids power dam at St. Maurice River, Quebec.

In ten short years, Art has climbed rapidly in his profession. Just back from a 2,500-mile editorial trip to Canada, here's what he has to say:

"To me, journalism is a form of teaching. Backed by the world-wide resources of McGraw-Hill, through travel, by working with leading engineers, I report on what's new and significant in engineering and construction. I try to make my articles more than instructive—to inspire readers to tackle and solve projects they might otherwise shy away from."

Other than preparing reports in college, Art had no early writing experience. Immediately after graduation, he was employed by a leading firm of consulting engineers. While on the job his appreciation for the inspiration-power of the industrial magazine



Cranes and Concrete. Another view of the Beaumont Rapids project. Art drove 1,800 miles from Montreal to get three on-site stories. Like other McGraw-Hill editors he got his story *firsthand.*

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grew, and in less than a year he applied for a position with McGraw-Hill.

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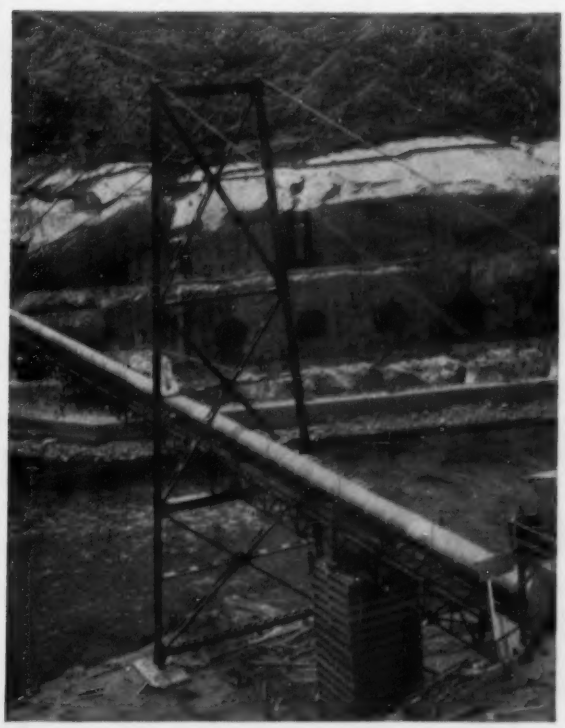
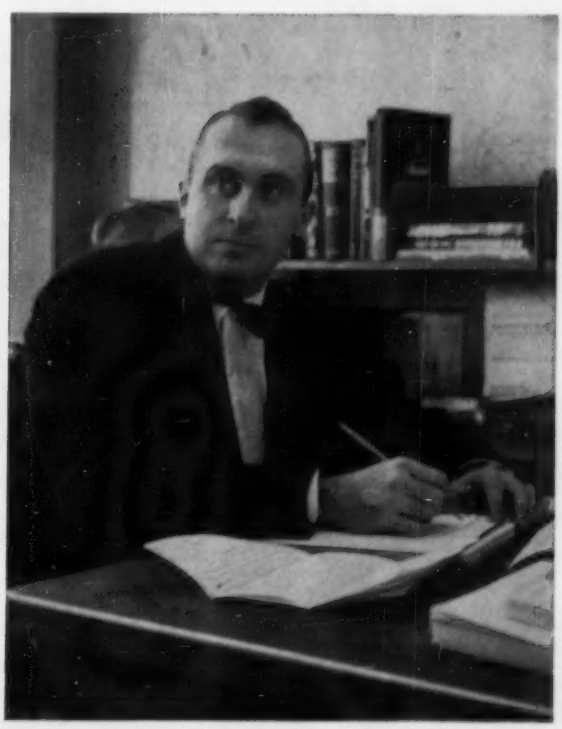


Dams and Tunnels. Here's a shot Art took of work on the Bersimis Powerhouse. As a McGraw-Hill engineer-journalist, you, too, will expand your professional background while reporting to your industry.



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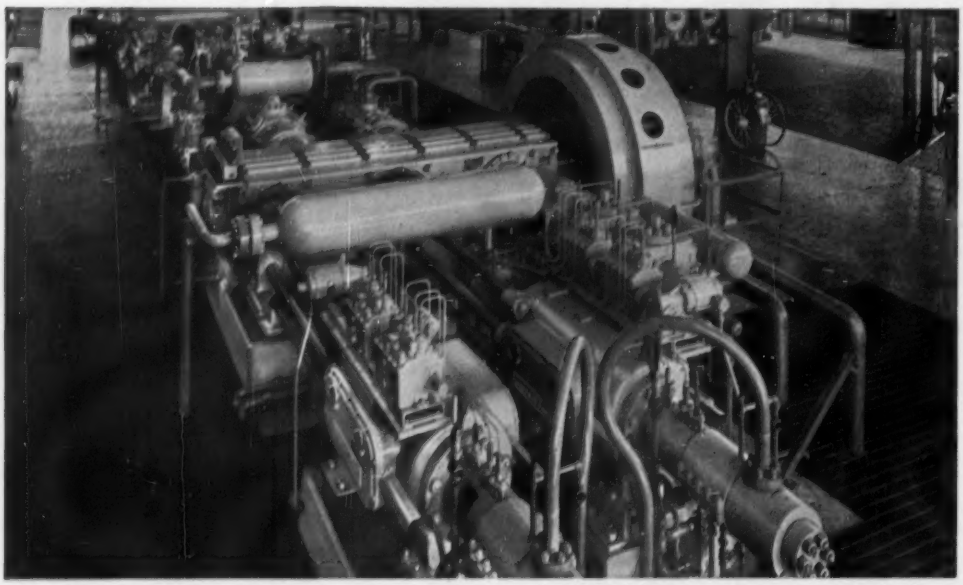

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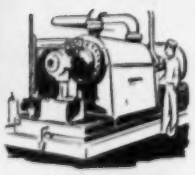

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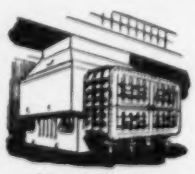

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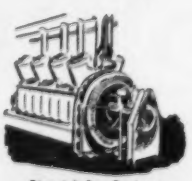

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Harvey Graves (Dartmouth, BA '50, MSEE '51) discusses a reactor experiment at the Westinghouse Reactor Evaluation Center, in Waltz Mill, Pa. As manager of the Nuclear Design Section, Mr. Graves works with Dr. Wilfried Bergmann (Vienna, PhD '51), on right, and other young scientists who operate the facility.

At 30, Harvey Graves directs nuclear design of two major Westinghouse reactors

After completing the Westinghouse Student Training Course in 1951, Harvey Graves attended the Westinghouse Advanced Design Course* and was sent by Westinghouse to the Oak Ridge School of Reactor Technology for one year. Back at Westinghouse again in 1953, Engineer Graves did advanced work on nuclear reactor development.

In 1955, he was promoted to supervisory engineer on the Belgian reactor project. In 1956, he was again promoted to Manager, Westinghouse Nuclear Design Section. Today, Mr. Graves' 24-man section is developing and designing the nuclear portion of commercial reactors for the Yankee Atomic Electric Company and the Center d'Etude de l'Energie Nucléaire in Belgium.

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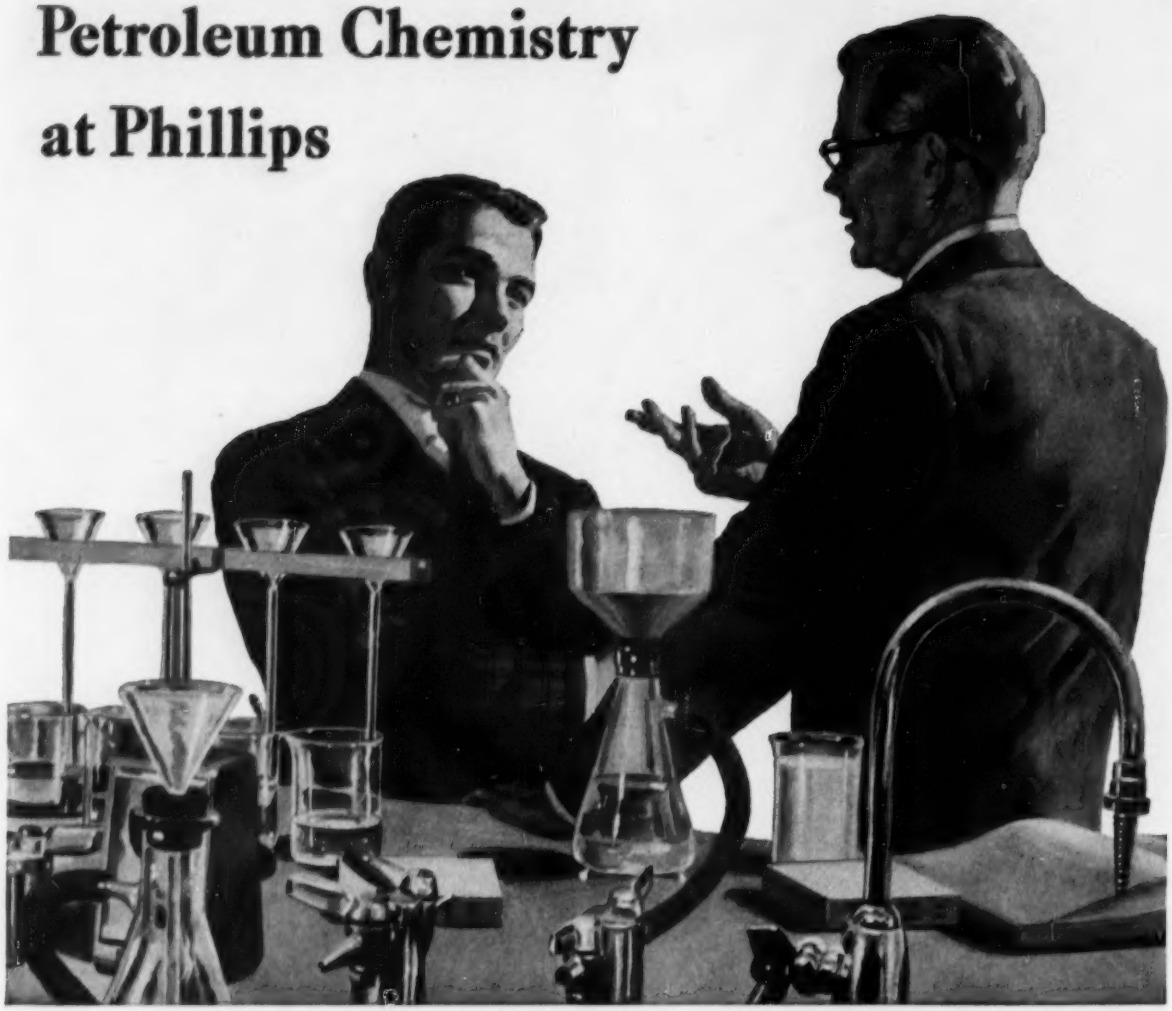

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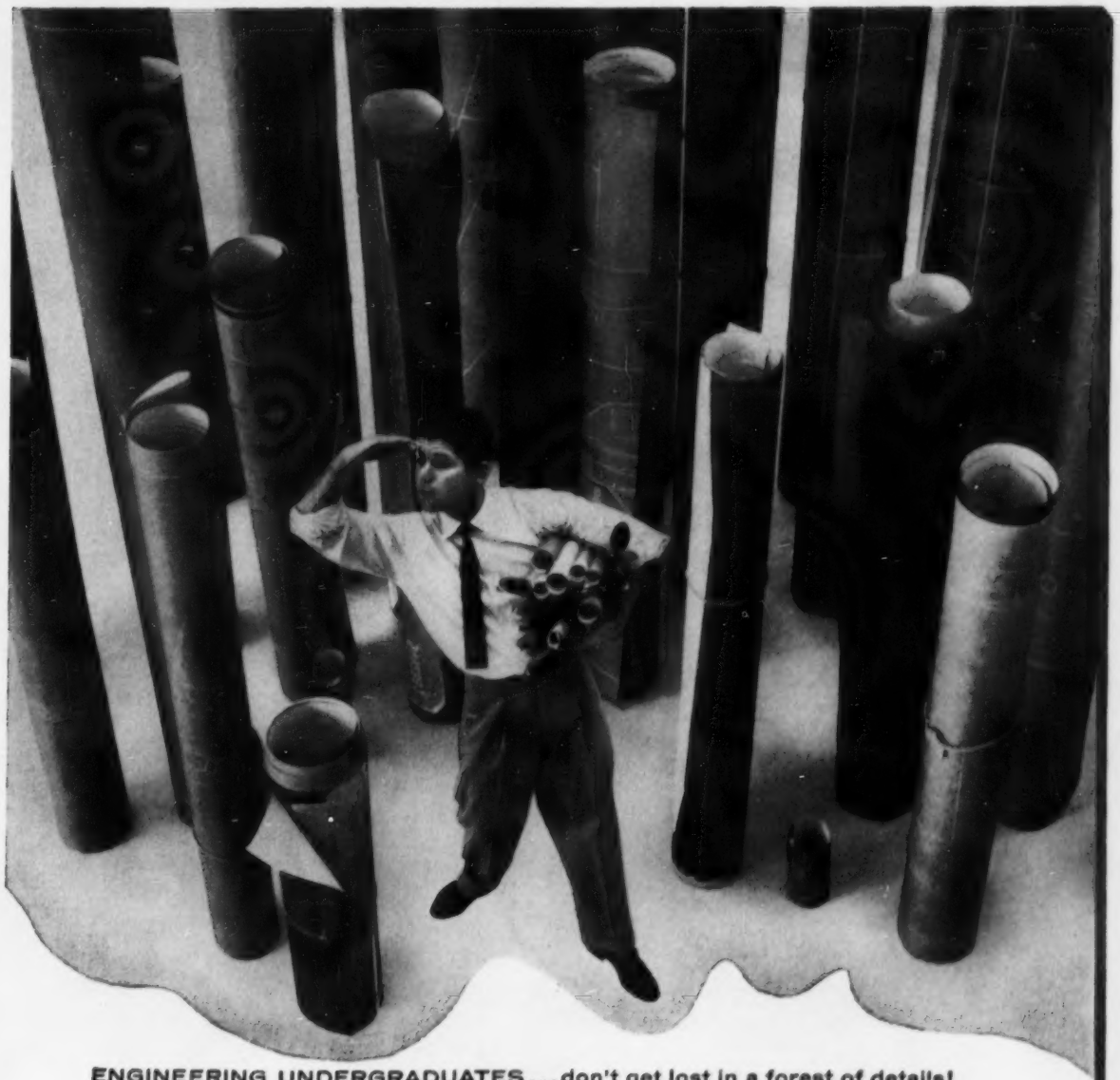

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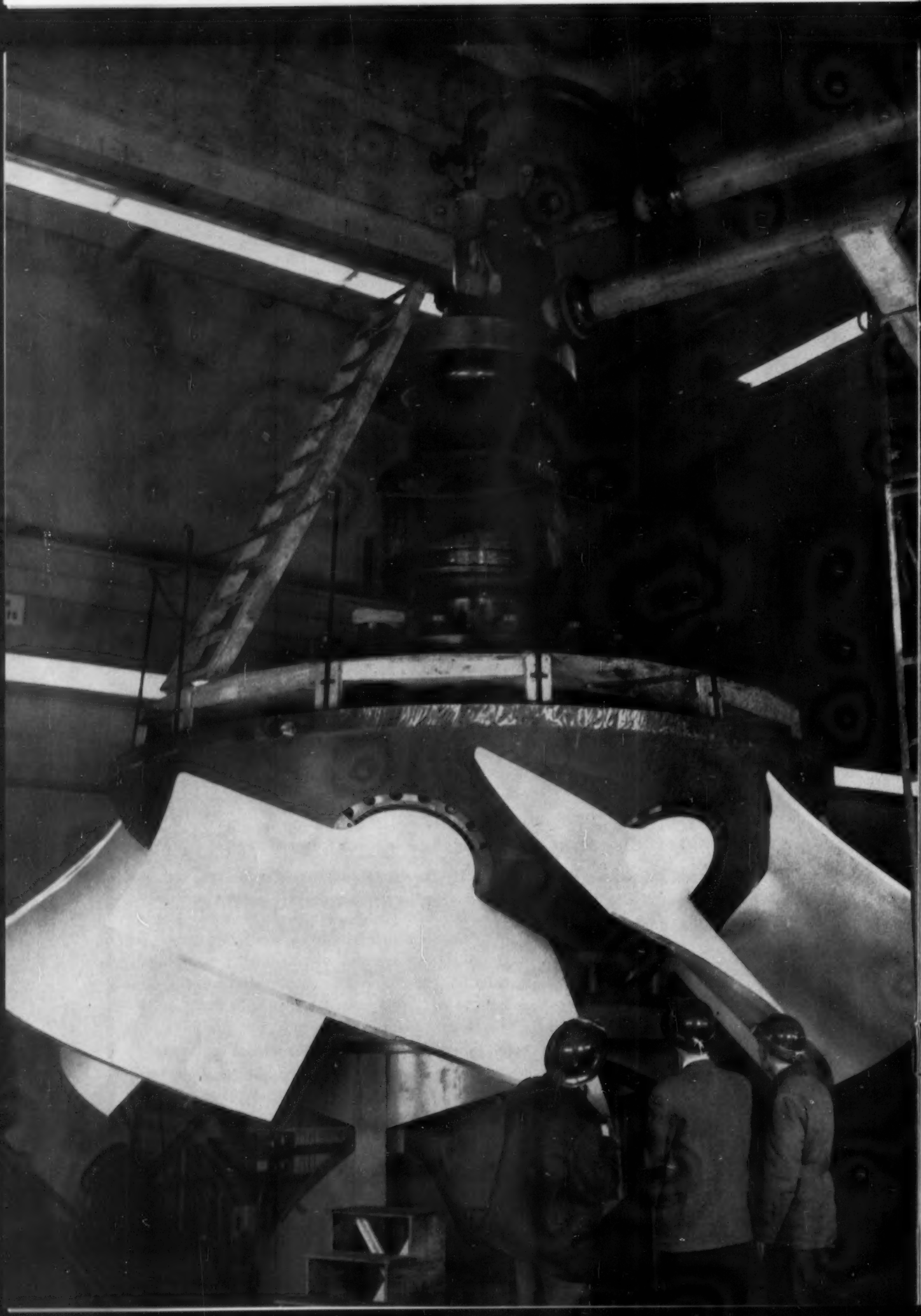
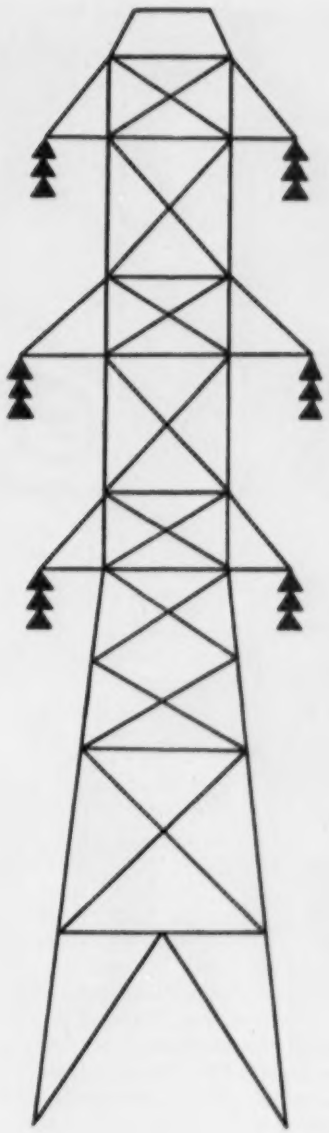


KILOWATTS ON TAP

by

Robert J. Loane, EE '60

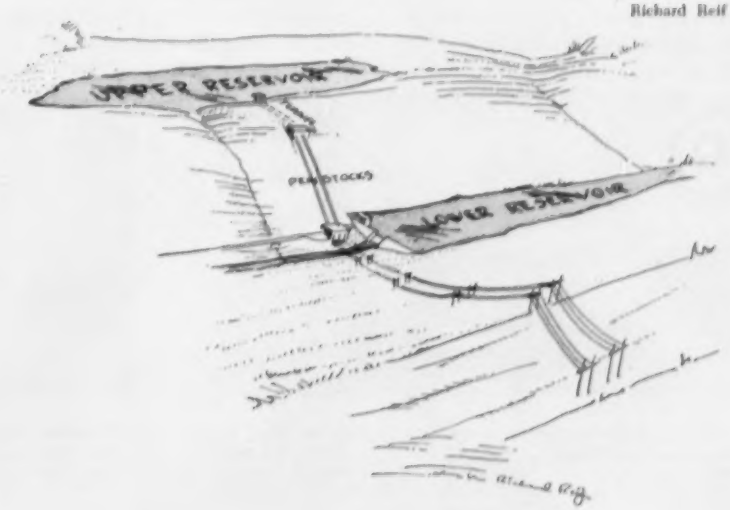


An often cited and unique characteristic of the electric utility industry is the fact that its product must be produced at the instant it is delivered and consumed. Furthermore, the numerous, independent-minded customers, rather than the suppliers of service, are the ones who determine just when that consumption shall take place. The usual means of generating electricity in commercial quantities, either by water power or by use of conventional fuels, have been adapted to fulfilling this requirement. It may, however, not always be possible to meet this need, either because of the economical or physical limitations of the available primary sources of power supply. A look ahead at some of the much discussed energy resources of the future shows why this may be so.

Nuclear fuels may supplement, and in some places supplant the use of fossil fuels. Ultimately, the inexhaustible energy of the sun, tides, and wind will have to be put to work in ever increasing amounts. Because of its high first cost, the economic use of nuclear power appears to require a base load operation, or the supply of energy at reasonably constant output. On the other hand, power that depends on solar heat, tides, or wind will not be available all of the time. Under such conditions, the effective use of the available energy will require either a continued use of existing steam and hydro plants for peak loads and stand-by service, the development of a reliable and economical means of energy storage, or else a radical change in some of our habits.

The storage of readily available energy in large quantities may, therefore, become much more important in the future operations of electric power systems; but it is definitely not a matter which has only future interest for tomorrow's engineers. Years ago, it was found that the storage of hydraulic energy by the pumping of water into an elevated reservoir was a simple, practical, and relatively economi-

Richard Reif



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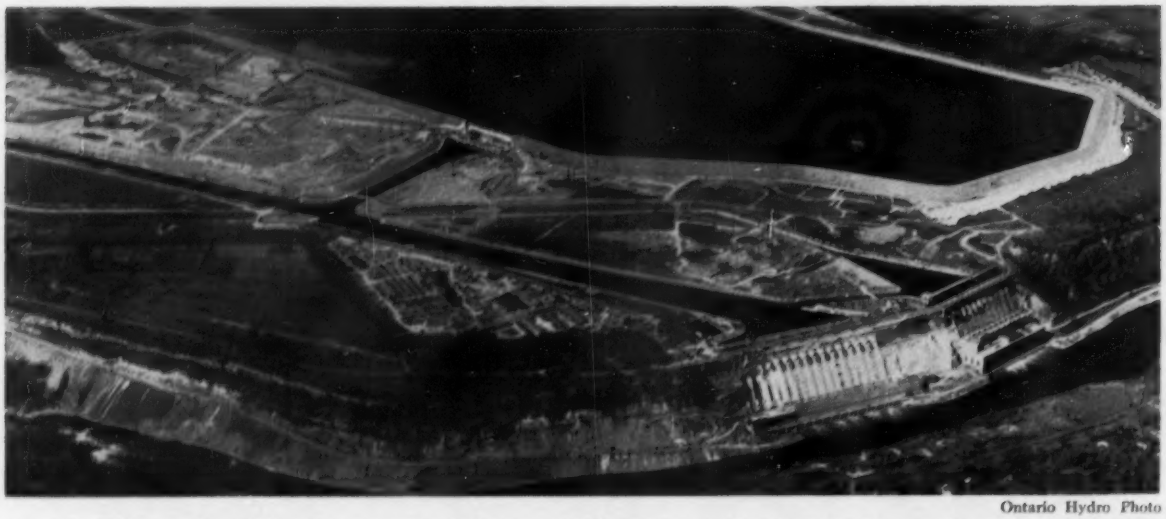
The Deriaz, or Feathering Francis, Pump-Turbine Impeller/Runner, used at Sir Adam Beck #2 at Niagara Falls.

Ontario Hydro Photo

→

This sketch illustrates the type of pumped-storage project planned for construction in New Jersey.



Ontario Hydro Photo

Air view of the pumping plant and storage reservoir at Niagara Falls, Ontario in Canada. Water is pumped from the canal into the reservoir at night. During the day it is used both at the pumping plant and at Sir Adam Beck #2 located on the river.

cal operation. Today, the utility industry is taking a renewed interest in pumped-storage hydroelectric power; most of the time for reasons of economy but occasionally and increasingly often because of physical necessity.

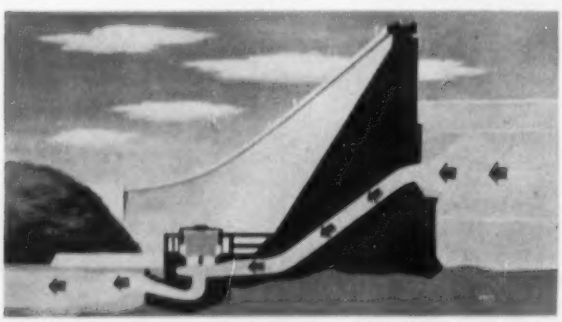
The designation "pumped-storage" is applied broadly to a hydroelectric unit, plant, or system wherein all or part of the water used for generation must be pumped into an upper reservoir before it becomes available for energy production. In some pumped-storage systems, the pumping head may be less than the head through which the available water is ultimately used for power generation. These represent very favorable situations as far as economic justification is concerned, and may be found where water is diverted by pumping from one watershed for use under higher heads in some other drainage area. Similar special advantage exists where water stored by pumping on a seasonal basis, or even on a daily basis, is released for use not only in the pumping plant but also in other downstream developments.

Pumped Storage at Niagara

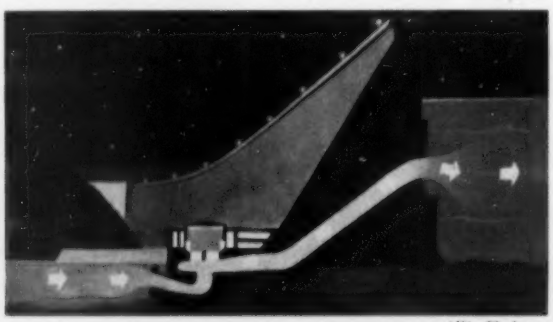
Not too far from Cornell, such a pumped-storage is planned for early construction by the New York State Power Authority. A few miles farther away, on the other side of the Niagara River, the first unit of a similar plant belonging to the Hydroelectric Power Commission of Ontario went into service in August of 1957.

The treaty which permits the diversion of water at Niagara for power generation requires that a minimum of 100,000 cubic feet per second flow over the Falls between 8 a.m. and 10 p.m. of each day from April 1 to September 16. From September 16 to October 31, this daily period is reduced by two hours. At other times a minimum of 50,000 cfs must flow over the Falls. All water in excess of these minima may be used for power generation. This requirement, which protects the beauty of the Falls in the April to October tourist period, makes the greatest amount of water available for diversion at times of lowest daily demand for power. The amount of energy available for peak loads is increased by the pumped-storage feature, which provides for the storage of the water during periods of maximum diversion and the release of the water when it is needed.

On the Ontario side of the river, a storage reservoir has been built adjacent to and seventy feet above the Queenston end of the power canal to provide a useful



***Changing water power to electricity*—During the day, when homes and factories make their biggest demands for electricity, water cascades down the penstock, whirls through the spiral casing and sets the turbine spinning in one direction to generate power.**



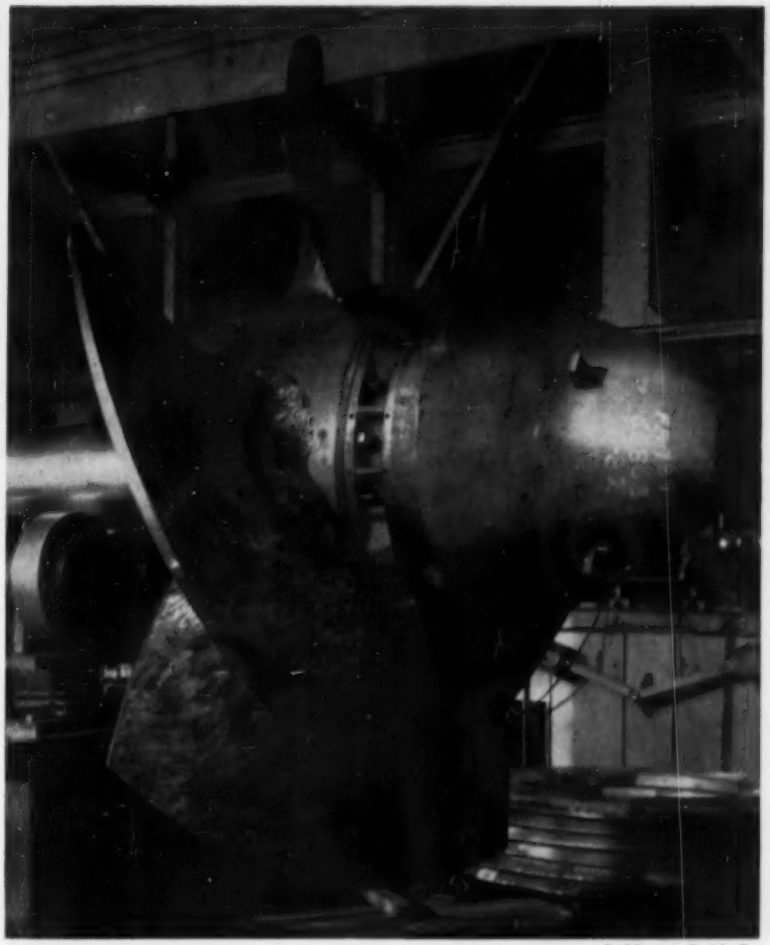
Allis-Chalmers

***Changing electricity back to stored water power*—At night, when power demands are low, electricity from other plants flows back to the generator-motor, which now turns the unit in the reverse direction to pump water back into the upper reservoir.**

storage of 15,500 acre feet of water. The filling of this reservoir will be accomplished nightly by pumping with six reversible pump-turbine units, which in themselves add 170,000 KW to the generating capacity of the project during the subsequent release of water from storage. In addition, this water is then used through a head of 300 feet in the Sir Adam Beck Station.

The proposed development at Lewiston, on the New York side of the border, would be similar, but somewhat larger. The pumping plant would be designed to house twelve reversible units, each rated at 20,000 KW as generators and 28,000 KW as motors.

There are two very special circumstances which lead to the development of pumped-storage at Niagara. The availability of maximum water quantities at the times of minimum power demands makes storage highly desirable; and the fact that the required pumping head is but a small part of the total head available for generation makes the operation very economical. It is just such special circumstances that have often justified the development of pumped-storage in the past.



S. Morgan Smith Co.

Another type of pump-turbine impeller/runner: the adjustable blade Kaplan, used at Traicao in Brazil.

Early Development of Pumped Storage

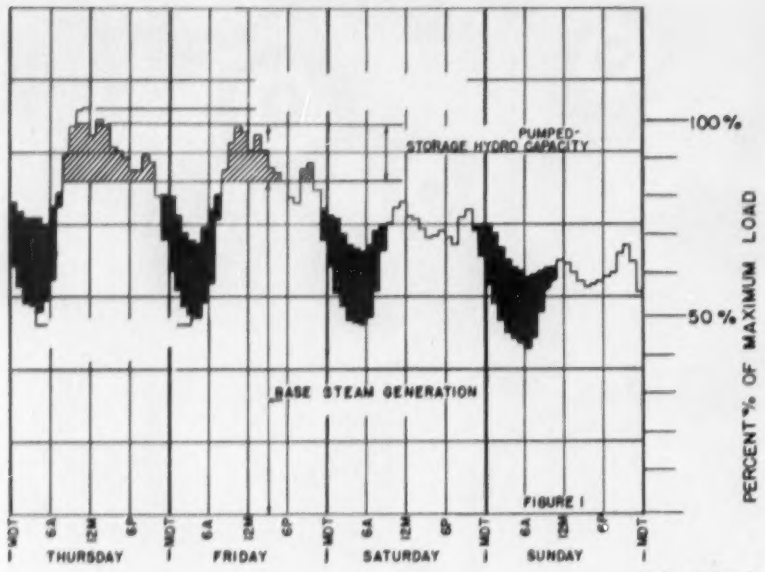
According to a survey of pumped-storage developments published in 1934, a hydro-mechanical pumped-storage installation was in operation in 1885. This early development probably consisted of a water-wheel driven pump, operating on a run-of-river basis, which was used to store water at some higher elevation for the operation of a mill when the natural stream flow was inadequate. The electrification of pumped-storage was first accomplished on the Tresa River in Italy around 1894, where at least part of the water was pumped through only 112 feet to permit its use for generation through 210 feet; the plant capacity is reported as seventy-one h.p.

This concept of pumping through a small head to provide, by diversion, for the use of a larger head was also incorporated in the first electric pumped-storage plant in the United States which was built in 1913.

In Europe, pumped-storage has developed rapidly since World War I; and the total generating capacity operating wholly or partly on pumped water is now in excess of 1,000,000 KW. Early hydro systems began to find means of using excess energy generated during periods of low demand to increase their capacity for peak loads. This was accomplished by pumping, either for diversion or storage, using the energy that would have otherwise been wasted. Diversion was popular in mountainous areas, where high heads could be easily obtained. For example, one plant in Switzerland obtained a head in excess of 5000 feet. However, in lower areas of Europe, pumping simply for storage rather than for diversion was widely used.

One of the earliest, and for many years largest, plants built solely for energy storage, was Herdecke on the Ruhr, finished in 1930. The development consisted of a reservoir located about 500 feet above the river, providing storage for fifty-two billion cubic feet. Penstocks ran from the reservoir to the powerhouse located on the river. Here were installed four units consisting of a pump, a turbine and a generator-motor all on the same horizontal shaft.

The operation of the Herdecke plant was the same as the operation of many pumped-storage plants of today. Since the purpose of the plant was to store excess energy, pumping was carried out during periods of low demand. When peak load conditions were reached, the stored energy of the water was converted back into electrical energy. The ratio of energy used for pumping to energy returned to the system was about three to two for this and many other similar plants.



Richard Epstein

A typical summer load curve, showing how pumped storage is used to provide peak energy. The black area represents energy used for pumping and the shaded area, the energy returned to the system.

Just two years before Herdecke, the second pumped-storage development in the United States, Rocky River, was built by the Connecticutt Light and Power Company to provide storage on a seasonal basis, not only for itself, but also for other plants located downstream. Pumping was carried out during the winter and the high flow season in the spring. During the summer, water was released to maintain adequate flow to other plants downstream. The generating to pumping energy ratio for Rocky River was only 61 per cent but when the other plant located downstream was also considered, this ratio rose to 79 per cent. Surveys carried out at the time of construction indicated that if other sites located farther downstream were developed the system could recover 111 KWH for every 100 KWH used in the pumps at Rocky River! In 1952 the two pumps were converted to reversible pump turbines, thus increasing the capacity of the system.

Four years later, in 1932, a third pumped-storage plant was built in this country as part of a scheme to provide diversion from the Susquehanna to the Finger Lakes drainage. The presence of a natural gas field near Lake Keuka in southern New York state caused the development of a unique storage combination. Gas was used to drive four generators having a total capacity of 6,600 h.p. During off-peak hours, this energy was supplied to three pumps totaling 3,000 h.p. which pumped water from Keuka Lake into Lake Lamoka. During on-peak hours, this stored energy was used in parallel with the energy taken from the gas engine generators.

From 1932 until 1950 no new pumped-storage plants were constructed in the United States. In 1950, the Lower Colorado River Authority installed a separate pump and turbine at Buchanan Dam in Texas. This pump made possible the addition of another unit to a plant that was already using most of the river's flow.

The Colorado-Big Thompson project, built shortly afterwards, uses the pumped water from Granby Reservoir for diversion to the eastern slope of the Rockies. Water is first pumped a maximum of 186 feet from Granby Reservoir, located on the headwaters of the Colorado River into Shadow Mt. Reservoir and Grand Lake. From this storage, water flows thirteen miles through the Alva B. Adams tunnel under the Continental Divide, and is then available for power generation through a drop of almost 3,000 feet, developed in a series of plants, as well as for its major use in irrigation.

The most recent American pumped-storage installation was the addition of a pump-turbine in the Hiwassee plant of TVA early in 1956. This 80,000 h.p. unit, the world's largest reversible pump-turbine, was installed instead of a conventional unit because of the additional peak energy it could supply during periods of low flow. In addition, the increased flexibility of system operation and the greater difference between on- and off-peak energy costs made a pump-turbine particularly attractive.

Much of the recently renewed interest in pumped-storage results from the development of the reversible pump-turbine, a single hydraulic unit which can be used with good efficiency for both the pumping and generating functions. There are several types of such units; that at Hiwassee, for example, being similar to the Francis type, except that the runner has been built with fewer and longer blades, making it more like a pump impeller. Other features were also modified because of this dual capacity. The unit is started as a pump by depressing the water below the runner with air and connecting the motor to a reduced voltage tap on the transformer. Automatic controls shift the unit over to full voltage when the proper speed is reached. The pump is then primed by permitting water to re-enter the impeller, and the gates are opened to start the pumping cycle. Its operation as a turbine is no different from that of conventional units.

At the Niagara plant of the New York State Power Authority, similar reversible Francis units will be

used; but in Canada, for almost the same conditions, another type of unit has been built. This is the Deriaz pump-turbine, or feathering Francis type unit, in which the blade angle is automatically adjustable and which has special advantages under widely varying heads. This differs in some respects from the better known adjustable blade propellor, or Kaplan units, which have been used as pump-turbines in a number of installations in Brazil.

Prospects for Future Pumped-Storage

If favorable sites are available, then pumped-storage systems in which all the available water is simply recirculated between the upper and lower reservoirs may be developed in large sizes at relatively low cost. It is this uncomplicated type of operation, which is not dependent on diversion or other special advantages, that potentially has the greatest interest for utilities in the East.

The necessity for substantially lower cost than is characteristic of conventional hydro plants determines the type of plant that holds promise of economical development. For a typical large high head plant the cost of the dam, reservoir and waterway constitutes about 75 per cent of the total plant cost. Fortunately, these facilities need not be the same in all hydro projects and it is in these items that the major savings of pumped-storage can be accomplished.

These savings stem from the relatively low storage capacity that must be provided, and the further fact that pumped-storage is practically independent of any substantial stream flow. For example, a pumped-storage project now under study in New Jersey, which combines both power and water supply in a single development, has been based on a storage requirement of ten to twelve hours of operation at full load. In contrast, a conventional hydro plant in northern Pennsylvania has a reservoir capacity that provides for 1000 hours of full load operation.

The small reservoir and the reuse of water makes pumped-storage on small streams possible. The only requirement for the stream flow is that it offset losses due to evaporation and leakage. The proposed pumped-storage in New Jersey is located on less than twenty-five square miles of drainage area. If water supply were not involved, this could have been reduced to five square miles or less. On the other hand, a conventional plant in the same location and having the same size and head would require over 250 square miles.

The proposed New Jersey project would develop a head of about 400 feet, and it is possible to do this between two reservoirs that are only about 4,000 feet apart. The total length of pressure conduit involved in the development would be less than 2,000 feet. There are no sites in this area where such favorable conditions could be developed in a conventional fashion, which would require a stream with 250 square miles of drainage, a reservoir for storage of perhaps 250,000 acre feet, and topography that provides for 400 feet of fall in a relatively short distance.

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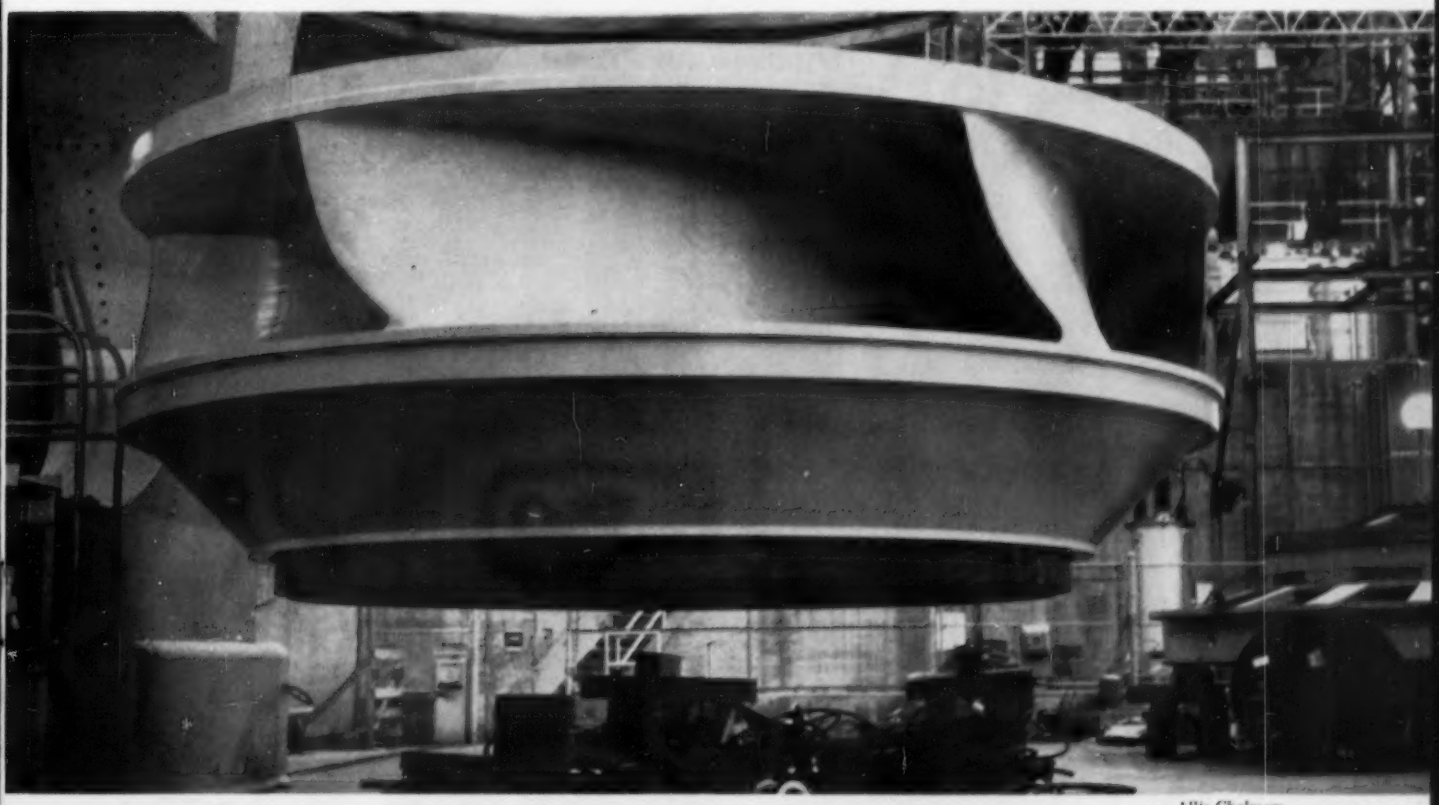


Allis-Chalmers

The Francis Pump-Turbine Impeller/Runner, used at TVA's Hiwassee Dam.

BOOLEAN ALGEBRA

by

Peter H. Jedel, EE '61

Over a hundred years ago George Boole laid the foundations for the solutions of many complex problems that exist in modern telephone switching and computing systems. Boole's idea was to reduce complex verbal propositions into a set of elementary symbols that were suitable for mathematical operations. He converted the declaration of a proposition from speech into mathematical terminology.

Basic Definitions

By substituting a letter for an entire statement, the statement can be replaced by a simpler expression. After replacing the isolated statements, it is necessary to connect those that are related to each other and in this way form a logical build up of thoughts. The words "and" and "or" are used most frequently in everyday speech to connect similar statements; therefore, it would be necessary to replace these by symbols. Boole proposed the plus for the word "or" and the dot for the word "and." The equality sign was given the meaning that the truth of the statement on one side of the equality sign depended on the truth of the statement on the other side of the sign. That is if we had the equation $W=T+S$ it would mean that W is true if $T+S$ is true. Bearing in mind that the plus sign means "or," the equation reads, "The statement W is true if either T or S is true."

If we say that a football team will win if they have a good running attack or good passing, what we mean to say is that if either of these two things develops then we have a winning team. This is easily translated into an equation similar to the one outlined above. Letting a victory be represented by V, good passing by P, and a good running attack by R, then we have a Boolean type equation: $V=P+R$. This says that either good passing or good running is enough to insure victory.

A different type of statement would be the following: I can solve that problem if I have my book, a pen, and my slide rule. This is an equation of the type $S=B \cdot P \cdot Sr$. and can be translated to read solution of problem depends upon having book **and** pen **and** slide rule. This statement also means that if anyone of the items is missing that the solution is impossible. Thus Boole has proposed symbols for the two conjunctives *and*, and *or* and has given the equality sign a new definition.

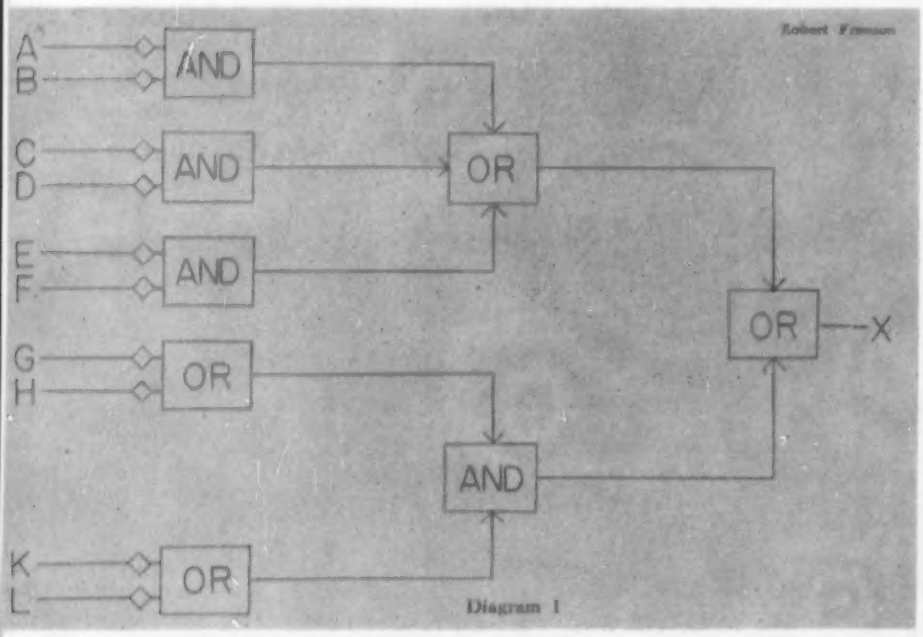


Diagram 1

Modern Practical Uses

Recently Boolean Algebra has been extended to deal with electronic circuits. There are two types of circuits that are widely used in modern day electronics that lend themselves easily to Boolean algebra. They are called "AND" circuits and "OR" circuits and are used especially in electronic data processing equipment. The outputs of these circuits depend directly on the inputs, and, by the use of Boolean algebra, it is possible to decide which of the inputs to make high so that the output will be high. If we now concern ourselves with the voltage level of the outputs of these circuits, we find that an "AND" circuit will give a high voltage only if ALL of its inputs are high. However, an "OR" circuit will give a high voltage if any of its inputs are high. These circuits fit very nicely into the equations we have developed for Boolean algebra. For example if we had an "OR" circuit as in diagram 1,
then if we wanted the voltage level to be high at x, we would have to have either A, B or C have a high voltage. This is expressed in Boolean terms by saying $X=A+B+C$. However if we had an and circuit as in diagram 2,
then for x to be high we would have to have A and B and C all high. Or stating this in equation form $X=A \cdot B \cdot C$.

Boolean algebra is not limited to simple diagrams but can be expanded to cover as large and complicated a diagram as one wishes. In diagram number 3 we have four "ANDS" and four "OR" circuits. We

could have had more or as many as we wished. From the diagram and the solution of what x depends upon we can now decide the best way of securing the highest voltage at x. If we assume that every thing else has already been taken into account then we find that the highest voltage level at x is obtained by having (A.B) or (C.D) or (E.F) at high potential. These combinations are chosen since we have assumed that all the leads are equal and therefore it would be easier to raise two wires to high potential than all the wires. Thus, through the use of Boolean algebra, we have been able to save ourselves many calculations and have arrived at the most practical way of achieving the highest voltage.

Negatives

Boole realized that there might arise the need for the negative of a statement. Common use of the negative arises in every day talk, "It will not snow today if the sun is out and the temperature is about 50 degrees." Boole defined the negative of a statement as the true statement with a bar over it. This would be read as not A for $\bar{A}$, not B for $\bar{B}$. etc. The above statement would be translated into Boolean terms to read as follows, $\bar{S}=Su+T$ where S stands for snow, Su for sun and T for temperature above 50 degrees. The primary use of the negative occurs in relay circuits. In order to operate a relay, its normal condition must be changed. If we had the situation shown in diagram 4 where A is open, B is closed, and C is open. To close the circuit, A must be closed and B left alone or C closed. This is expressed by saying, A $(\bar{B}+C)$, or we need A, and either not B (Leave B alone) or C.

After we have described a network completely in Boolean terms, we may still find it too complicated to work with easily. There are a number of transformations one can make to convert the equation into something more desirable. I will list a few and others can be easily derived.

$$O+O=O$$
$$I+O=I$$
$$A+A=A$$
$$A\,.\,B=B\,.\,A$$
$$C(A\,.\,B)=B(A\,.\,C)$$

With the use of these and other similar simplifying expressions many circuits can be broken down and analyzed effectively.

In closing, it is interesting to note that at the time George Boole was teaching at Queen's College the telephone had not yet been invented and the digital computing machine in the form it now exists was inconceivable in the terms of the technology of the day. Yet it is in these very things that Boole's algebra finds its widest usage.

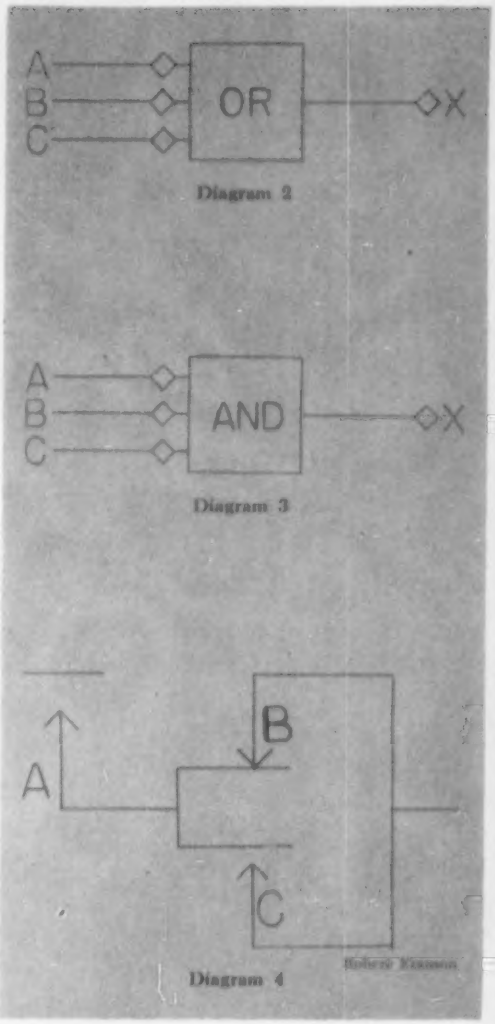


Diagram 2

Diagram 3

Diagram 4

KILOWATTS ON TAP

(Continued from Page 25)

With reservoirs and flow lines reduced to minimum sizes and lengths, a large part of the cost of the conventional high head hydro plant is avoided. Whereas a conventional hydro installation may cost two or more times as much as equivalent steam capacity, it is expected that pumped-storage may be developed, under proper conditions, at a unit cost below that of large modern steam units. The Ffestiniog plant in Wales is expected to cost about $115 per KW as compared with $200 per KW for steam generation. Estimates made in this country are believed to show a somewhat smaller advantage for the hydro capacity.

Although the initial cost of the hydro plant may be less than that of equivalent steam capacity, the same may not be true of annual operating costs. When pumped-storage is added to an existing utility system as an alternative to a modern steam unit, it is almost certain that the system production costs will be higher per unit of net output, since more fuel will be used in the system with pumped-storage. It is true that operation of the hydro plant, making use of low-cost off-peak energy for pumping, may replace high-cost steam generation in the peak portion of the load curve. The alternative new steam capacity, that might have been installed, can also replace this high-cost energy at a cost which does not include the losses in the pumping-generating cycle. This, however, is no cause for discouragement.

The higher fuel costs of the system may be offset in whole or in part by other cost advantages of the hydro. For plants of reasonable size, hydro operation and maintenance expenses will be less than the operation and maintenance (excluding fuel) for the alternative steam. Furthermore, because of the generally longer life of hydro equipment, depreciation costs should be less than for steam.

Based on an evaluation of both the fixed and operating costs, at least some utilities have come to the conclusion that pumped-storage provides an economical alternative to steam generation. Others have

(Continued on Page 33)

TITANIUM'S SUCCESS STORY

by

Roy J. Lamm, ChemE '61

A little over ten years ago titanium burst from obscurity onto the American industrial scene. Since then it has become an increasingly popular metal, until today it is replacing aluminum and steel in many applications. No ordinary metal, titanium possesses an unusual combination of properties, making it a highly useful material for an infinite number of applications.

Unique Properties

Silvery gray titanium is classified as a light weight metal, (density .16 lb/in^3), being 60 percent heavier than aluminum but only 56 per cent as heavy as alloy steel. Absolutely pure titanium has little value since it can only be produced in small batches at a high cost. In contrast, commercially pure titanium (99.5 percent Ti), really an alloy of the pure metal, is being mass produced at an ever decreasing cost.

Commercially pure titanium and other titanium base alloys are stronger than aluminum alloys and most alloy steels. This unique strength is accompanied by excellent ductility. As indicated by the graph, titanium alloys are far superior to the usual engineering metals and alloys in strength to weight ratio. Titanium is the only structural metal known to have an endurance limit consistently in excess of 50 percent of its tensile strength. Titanium alloys have much higher fatigue resistance than aluminum, higher even than steel. In addition it has a far lower linear coefficient of expansion and lower thermal conductivity than either of the other two metals. Erosion, cavitation, and wear tests put titanium in a class by itself. As for impact strength, the capacity to withstand mechanical shock, it is superior to aluminum and in some cases comparable to steel.

The corrosion resistant properties of titanium are remarkable. Its resistance to such troublesome materials as nitric acid, moist chlorine, solutions of chlorine, chlorinated organic compounds and inorganic chloride solutions is uniquely superior. Salt water and marine atmosphere have no effect on titanium whatsoever.

← The 4,000 pound ingot is remelted in an electrode furnace for further purification. It is then processed into bars, wire, or sheets. Here a large 4-inch reversing mill rolls continuous coils of titanium strip-sheet 48 inches wide.

Nature, however, abhors perfection, for titanium has some deficiencies that cannot be overlooked. Titanium alloys exhibit mediocre stress-rupture and creep performance upon continued exposure to temperatures above 1000°F. While this is much better than aluminum, it falls far short of high temperature alloy steel performance. It seems improbable that titanium alloys will ever be developed to withstand temperatures of 1500°F. and maintain reasonable stability. When in the molten state, titanium is a universal solvent of refractories; thus, special, expensive casting and welding methods had to be developed. In machining it has a marked tendency to seize upon other metals and hard substances. The only solution to this problem has been machining techniques employing low speeds and proper cooling.

Phenomenal Growth

The growth of the titanium industry is a surprising success story. No other metal has compressed so much technological and production development into such a short period of time.

Discovered in the late eighteenth century, the metal got little more than its name—titanium, from Titan, the mythical son of earth. After a century and a half of scientific progress "Ti" was merely a symbol on the periodic chart.

In 1946 the U.S. Bureau of Mines announced the successful operation of a pilot plant for the production of small batch lots of titanium. In 1947 the total production was two tons. Undaunted, the Bureau of Mines proceeded with its experiments and, with the aid of certain visionaries in the armed forces, who recognized the potentialities of the metal for defense purposes, finally convinced a few industries to investigate the metal. It did not take long for these organizations to recognize the metal's possibilities in non-defense as well as defense applications. Research was stepped up and in no time titanium had outgrown its infancy to become a wobbly adolescent.

Mass production of the metal presented engineering problems never before encountered. Its unique property of being a universal solvent, dissolving or contaminating every known refractory, made winning of the metal from its ore a rigorous procedure. In addition extreme purity is a necessity, for even small percentages of contaminants are fatal to its physical properties.

The 500 tons of titanium produced in 1950 made many believe the metal was doomed. But engineering began to pay off, and in 1953 a milestone was reached when a simple efficient reactor for sponge production was perfected that could produce titanium sponge at a reasonable cost.

The adolescent matured quickly with production doubling then tripling in ensuing years. Although final figures are not in yet for 1957, it is expected that 20,000 tons of sponge will be produced worth approximately 100 million dollars.

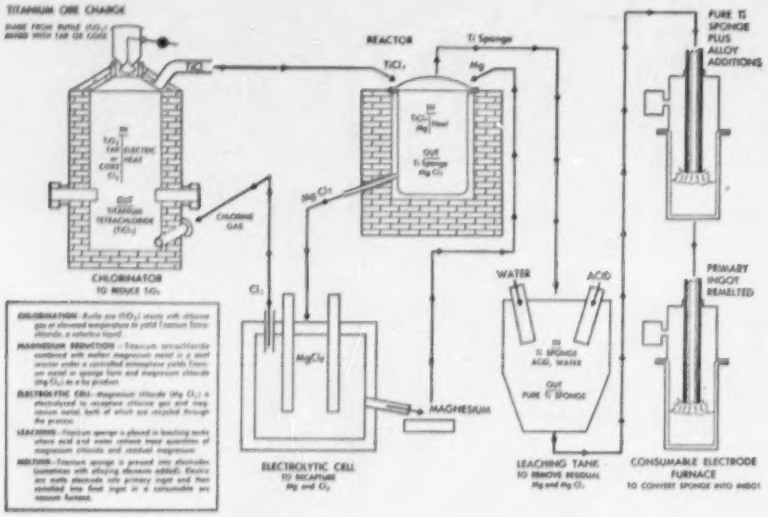
Production—A Rigorous Procedure

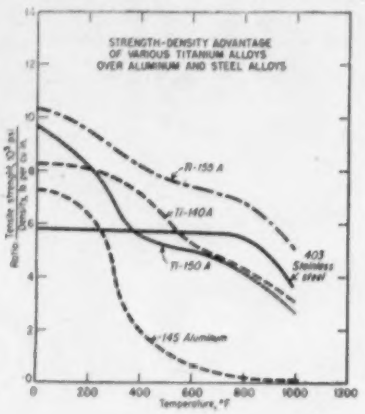
Titanium production is different, for it demands the skills of chemistry to produce the basic metal, and specialty steel fabrication knowledge to produce the finished ingot. Rich deposits of the metal, fourth most abundant element found in nature, lie within the borders of the U.S. These deposits, primarily rutile (TiO_2) and ilmenite ($FeTiO_3$), assure us of an ample supply of ore for many years.

Since the ore is found in sand or sandy soil, it is more economical to handle it as a slurry. Portable dredges and concentrating plants are set up at a rich deposit. The sand containing the ore is pumped from the dredge to the concentrating plant where the ore about 5 per cent of the total diggings is separated from the sand and dried.

With the present refining method only rutile ore is mined; however, research is being conducted in an attempt to utilize ilmenite ore in titanium production. After the rutile has been mined, it is shipped to a permanent plant where it is mixed with carbon and chlorinated. The products of this reaction are $TiCl_4$ and CO. The colorless $TiCl_4$

→ After being pressed into an ingot the sponge is fed into an electrode furnace and melted. The product is the 4,000 pound homogeneous ingot pictured here.





is pumped into a large retort where it is reduced by molten magnesium under an inert gas blanket, yielding titanium sponge and $MgCl_2$. The $MgCl_2$ is drawn off the bottom of the retort and electrolyzed to reproduce chlorine gas and metallic magnesium. The sponge is then pressed into ingots perhaps with alloying metals added in proper proportions and fed into a water-cooled copper crucible. An arc is struck by a titanium washer contacting the sponge and maintained by an increasing pool of molten metal in the crucible as the sponge electrodes are consumed. At the bottom of the crucible the titanium cools and is drawn off as an ingot. This ingot is remelted in a similar furnace to produce a finished ingot of commercially pure or alloyed titanium.

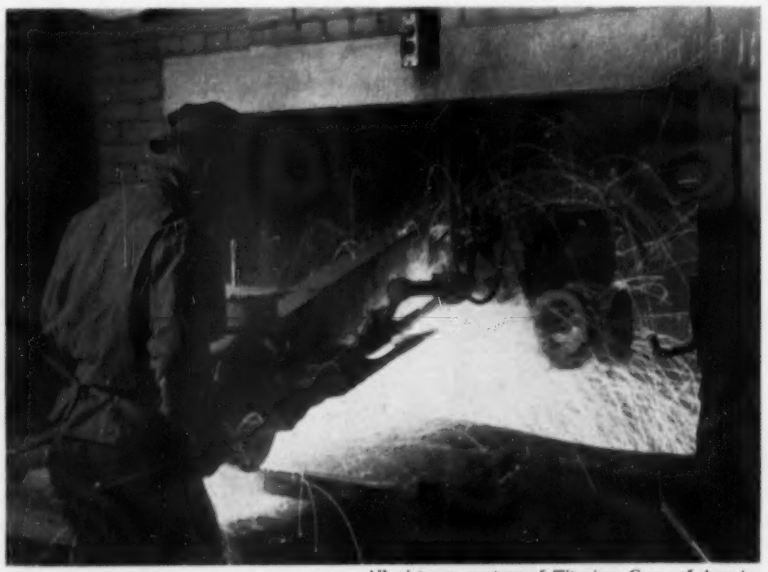
Applications

Titanium's valuable combination of properties make it a welcome newcomer to the industrial scene. To date, aircraft industries are accounting for well over half the titanium consumed yearly. All our modern jet propelled aircraft use large amounts of titanium in their frames and power plants. Its high strength to weight ratio at intermediate temperatures make it an ideal material replacing heavy steel fittings. Compressor blades, exhaust pipes and engine grips of titanium reduce a jet engine's weight by over two hundred pounds. Titanium airframes and fuselage skin are saving up to three hundred pounds in fighters and several thousand pounds in transcontinental bombers. At present titanium offers the only solution to the elevated temperatures encountered as aircraft approach the thermal barrier—a point where aluminum wilts and high temperature alloy steel imposes tremendous weight penalties.

The corrosion resistant properties of the metal account for the largest tonnage used in non-defense industries. Corrosion engineers, always in search of better materials, have recognized in titanium a solution to many of their worst problems. The life of steel fittings, pipes, and valves subject to bleaching agents or salt brine used to be measured in days. Similar parts fabricated of titanium are lasting indefinitely. Components of chemical equipment handling corrosive chlorine gas and dilute to medium concentration acids stand up months longer if made of titanium.

Unfortunately the high cost of titanium has limited its use in such applications. When the present price of approximately $10 a pound can be reduced, titanium will boom in non-defense industries.

Research and engineering continue by the makers of titanium in an effort to increase production and at the same time reduce the price. It appears to be only a matter of months before this change occurs. When this does happen titanium's success story will have been complete.



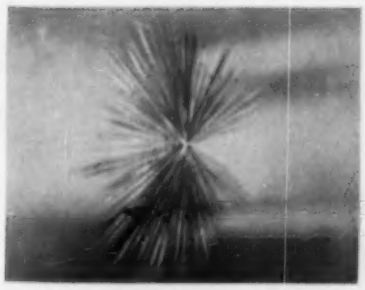
All pictures courtesy of Titanium Corp. of America

Surface conditioning of 4-inch square titanium bars. The grinding wheel throws off characteristic brilliant white sparks.

THE RADIO PROXIMITY FUZE

by

William B. Easton, EP '61



Use of a proximity-fuzed rocket against a radio-controlled target airplane. First picture: Sensitivity pattern of the fuze. Second Picture: High-explosive burst pattern.

A proximity fuze is a device designed to detonate a piece of ammunition at a predetermined distance from the target. The radio proximity fuze was developed in the United States during the Second World War and was one of the more important factors which spelled victory for the Allied Forces.

What is a fuze?

Every piece of ammunition, except small rifle shells, must be equipped with a fuze. The fuze is the "brains" of the piece of ammunition which explodes it at the proper time and place. Fuzes may be divided into four essential groups: impact, delay, time, and proximity.

The impact fuze is designed to explode its ammunition with as little delay as possible on hitting its target. The delay fuze, used primarily for piercing armor plate, is designed to function a predetermined time after it hits the target. The proximity fuze, representing a more advanced type than either of the above, can often be effective without hitting the target. As stated above, it is designed to function at a predetermined distance from the target.

The effectiveness of the proximity fuze as an air defense weapon can easily be appreciated. It is not necessary, as with contact fuzing, to actually hit the airplane; the only requirement is that the projectile approach the airplane within the lethal operating range of the fuze, usually sixty to seventy feet. This means that the effective target area is increased many times—by a factor of twenty to fifty for the average airplane. The proximity fuze, however, must be compared with time fuzes which had been developed previously to detonate after a predetermined time of flight, preferably in the vicinity of the target. To make effective use of a time fuze, it is necessary to determine the distance to the target quickly and accurately and to set the fuzes accordingly before firing. Modern radar ranging techniques have greatly increased the effectiveness of the time fuze; but even with the most accurate methods, the time fuze is only about one-fourth as effective as the proximity fuze. In addition, proximity fuzes have the following advantages:

1. No setting or adjustment of the fuze before firing is necessary.
2. All bursts are at approximately the proper point on the trajectory to inflict maximum damage on the target.
3. The fuze provides a considerable surprise factor because the pilot of the target aircraft usually is not aware that he is being shot at until he is hit.

The proximity fuze is also far more effective against most ground targets than the contact fuze. If a projectile can be made to explode

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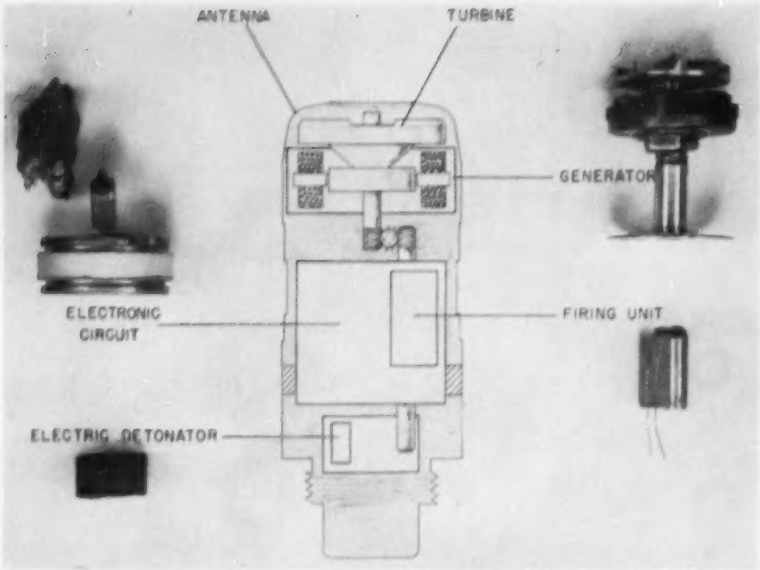
Third Picture: Sensitivity pattern and burst height of bar-type radio proximity bomb fuze. Fourth Picture: Actual high-explosive burst using proximity fuze. Notice how the fragments completely blanket the target.



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An early model proximity fuze developed for use on the "G.I. fox-hole cannon"—the 81-millimeter trench mortar shell. Notice the small size of the electronic components.

above the ground, fragments are sprayed out over a wide area instead of being buried in the ground at the point of contact or directed harmlessly upward.

History

The proximity fuze is entirely the result of work done in the United States. Work was started in August, 1940, under the auspices of the Office of Scientific Research and Development, Department of the Army. In spring, 1941, the Navy took responsibility for proximity fuzes in rotating projectiles. It was not until January, 1943, however, that the first proximity fuze was used against the enemy.

The central laboratories of the division of OSRD which developed fuzes for non-rotating projectiles were located at the National Bureau of Standards in Washington, D.C., under the direction of Mr. Harry Diamond. In September, 1943, Diamond Ordnance Fuze Laboratories was activated as a Class II field installation of the Army Ordnance Corps to continue the work of the Bureau of Standards.

Extreme security precautions accompanied the development of the proximity fuze, and every effort was made to keep the enemy from learning that we had succeeded in producing such a weapon. If the enemy had had these fuzes in any appreciable quantity, our own air offensive would have suffered greatly.

Until December, 1944, when proximity fuzes were used effectively to help stop Von Runstedt's counteroffensive, proximity fuzes were used only when there was no possibility of the enemy's recovering even one. The first use of the fuze was confined to localities where unexploded shells would fall into the ocean or in completely protected territory.

Method of operation

The main requirement of any proximity fuze is that it must respond to some sort of stimulus from the target. In the radio proximity fuzes of the Second World War, the stimulus is the reflection by the target of the radio signal sent out by the fuze. The important components of a fuze are an oscillator, an amplifier, a power supply, and a safety and arming device.

The oscillator is the heart of the radio proximity fuze in that it is the device which actually detects the target and develops the signal voltage. The target reflects a portion of the fuze's radiated energy back to the antenna. If the reflected wave is in such a phase as to induce an opposing current in the transmitting antenna, the antenna load is reduced and the radiation resistance increased. When the fuze comes a quarter wavelength closer, the antenna current is increased, and the radiation resistance is reduced. The variations in the signal voltage are amplified and used to trigger a thyratron, which, in turn, fires a detonator.

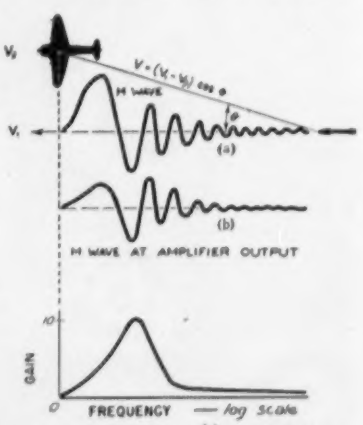
The amplifier, usually a single stage using a subminiature pentode, not only amplifies the small signal from the oscillator but also allows the incorporation of frequency selectivity to insure reliable operation and cut out noise.

The requirements of the power supply are quite severe. The most important limitation is that of size. Although scaled-down dry cells could be made to deliver the required power, they do not keep indefinitely and are not usable at temperatures of $-40\,^{\circ}C$, which are often encountered in bomb bays of airplanes at high altitudes. One method, often used in artillery shells, is to use wet cells with the electrolyte contained in a glass ampoule which breaks on firing. Bomb fuzes often use wind-driven generators to power the electronic circuit.

Safety

The primary design objective in a fuze is to make a fuzed projectile safe for troops to handle. As proximity fuzes are, by their very nature, sensitive to their surroundings, it is important that they be kept inoperative until the missiles carrying them are well away from their firing point.

The act of making a fuze opera-



Journal of Research of the National Bureau of Standards

(a) Reflected signal from aerial target. (b) Reflected signal as altered by fuze amplifier. (c) Frequency characteristic of the fuze amplifier.

tive so that it will detonate the missile when a triggering signal is received from the target is called *arming*. Arming, in proximity fuzes, consists of three stages:

1. Activation of the power supply.
2. Connection of the detonator to the fuze circuit.
3. Removal of a mechanical barrier between the detonator and the booster charge.

As all three of these stages must be completed before the projectile can be detonated, proximity fuzes are actually safer to handle than ordinary contact or time fuzes.

Design objectives

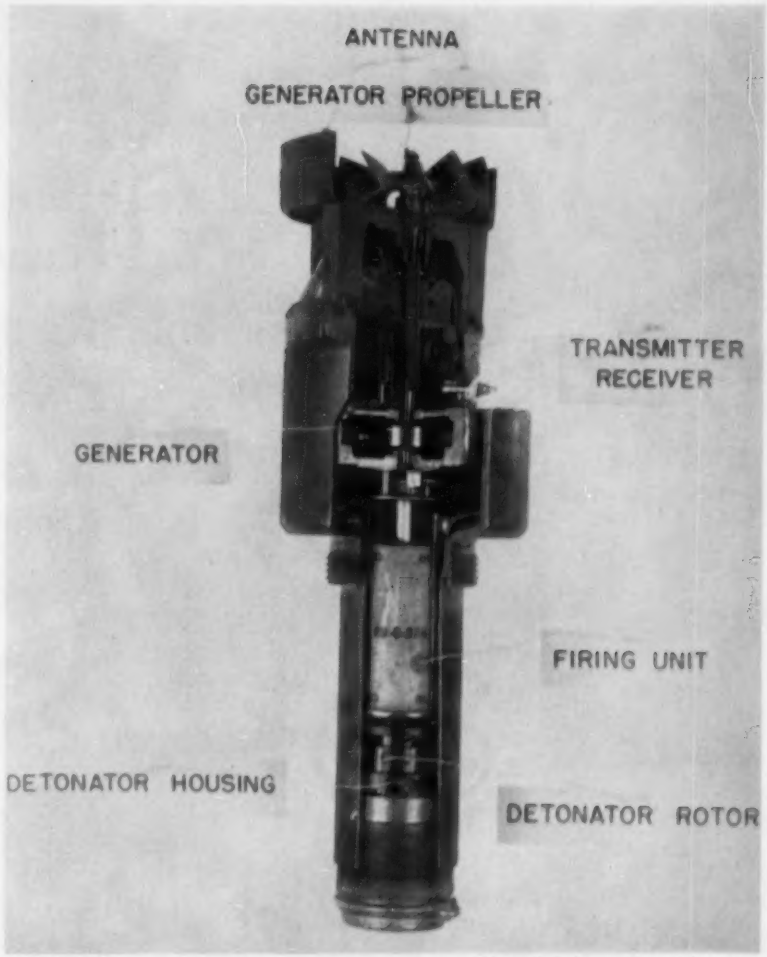
The physical size and shape of the proximity fuzes had to be the same as that of the earlier contact and time fuzes so that they could be used in bombs and shells already in production and without changes in the firing or launching devices. This naturally required miniaturization of the circuitry. Many of the developments in subminiature tubes and components was a direct result of proximity fuze research.

Ruggedness is also of prime importance, if a fuze is to be operative after being subjected to an acceleration of several thousand "g's" on firing. It is significant that, although Germany tried to develop proximity fuzes, her scientists were unable to develop tubes to resist such shocks. To the Army, a proximity fuze is "just another piece of ordnance," which should require no special care.

Cost is a very important factor for an item which is produced by the millions. Simplicity of design is conducive to lower cost: thus one instead of two stages in the amplifier, and so on.

Testing

As one operation destroys a fuze, it cannot be tested and adjusted for proper operation. Therefore, fuzes must be field tested in large numbers and the results studied by statistical methods. Thousands of tests were made at various proving grounds throughout the country. Added to this was the valuable information yielded by the enemy who, so obligingly, provided targets for tests under actual combat conditions.



Diamond Ordnance Fuze Laboratories

A ring-type radio proximity bomb fuze. Rotation of the propeller in the air stream drives the generator and operates the safety while the bomb is in flight to the target.

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The author wishes to thank the members of the staff of Diamond Ordnance Fuze Laboratories who helped him with this article.

KILOWATTS ON TAP

(Continued from Page 27)

undoubtedly reached a contrary conclusion, perhaps because of unfavorable site factors, or because of estimated production costs that are much higher than they would be with the addition of new and efficient steam generation. It is in these two areas that the largest difference might be expected.

If the economic studies show a close balance between the hydro and steam, the scales may be tipped in favor of hydro by consideration of its additional advantages, at least some of which are difficult to evaluate. For example:

1. Each KW of installed hydro capacity will replace more than one KW of steam capacity because station uses are less for hydro; and more important, the hydro unit has less outage time.

2. The shutting down of a large modern steam plant at light loads is almost impossible and for the older and smaller units, involves a hazard in their operation. Pumped-storage hydro can pick up and drop load almost instantaneously.

3. The hydro units can provide large reactive capacity for system voltage regulation. The units can

(Continued on Page 67)

Theodore J. Kauffeld, M. E., P. E.

Consulting Engineer

•

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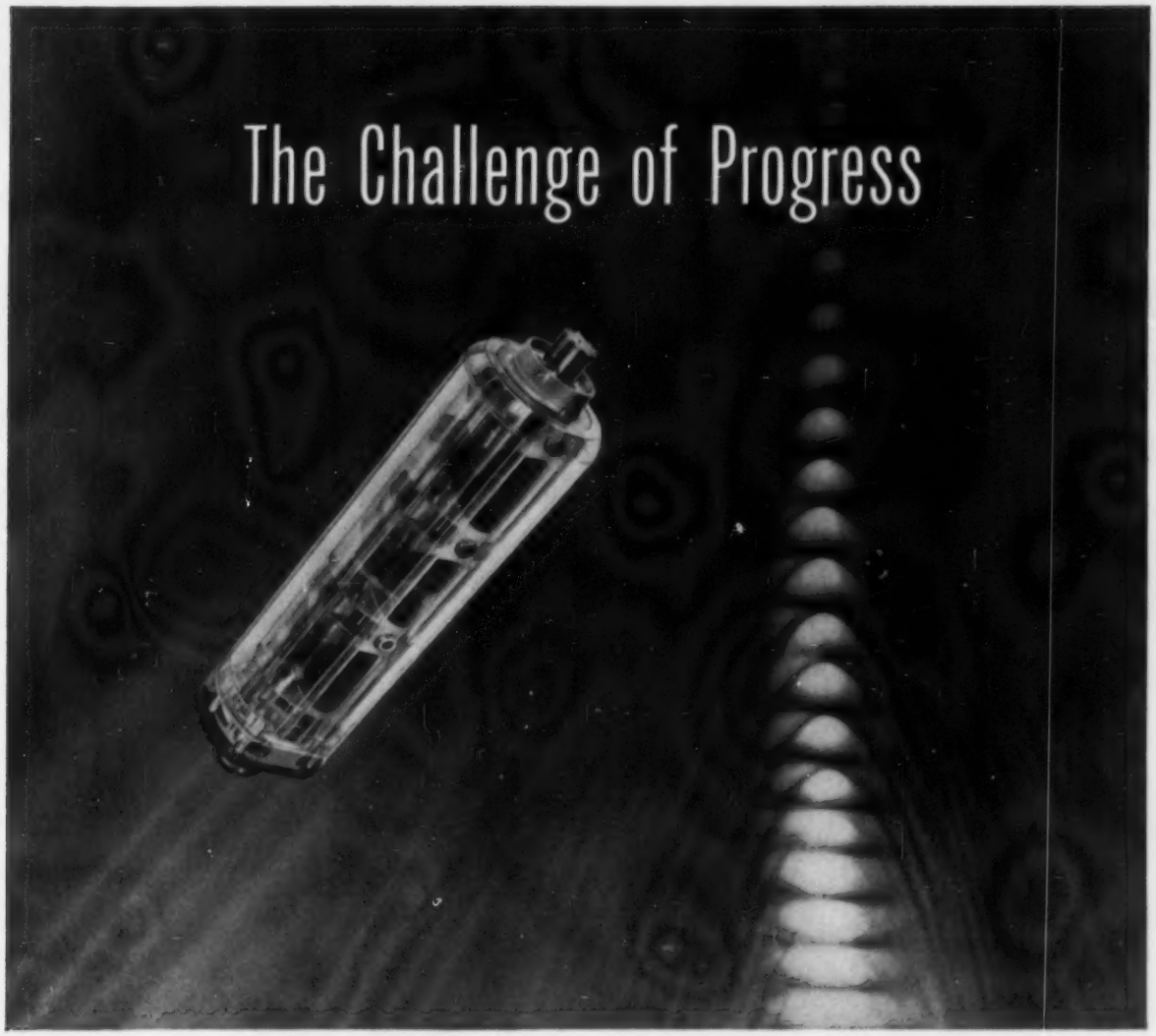
The Challenge of Progress



Recently AiResearch engineers were called upon to develop an accessory power motor for aircraft and missiles which would operate at +1000°F. . . . a temperature area where present-day hydraulic and electrical devices fail.

Their answer was this cam piston air motor, pictured above in a specially built transparent shell. Operating on hot air or gas, its efficiency actually increases as temperatures rise.

This problem and its solution are typical of many encountered at AiResearch in aircraft, missile, nuclear and electronic fields. Specifically, you'll find them in system electronics; computers and flight instruments; gas turbine engines and turbine motors; cryogenic and nuclear systems; pneumatic valves; servo control units and air motors; industrial turbochargers; air conditioning and pressurization; and heat transfer.

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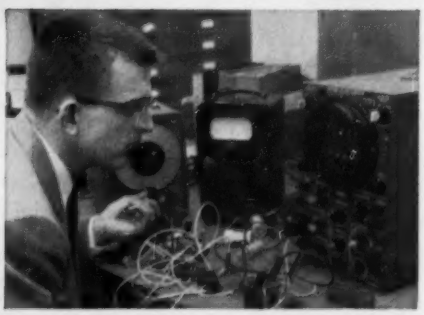
WHAT'S DOING at Pratt & Whitney Aircraft . . .



Pratt & Whitney Aircraft engineer checks a bread board model for a subminiature, encapsulated amplifier built with transistors.

A rig in one of the experimental test cells at P & W A 's Willgoos Laboratory. The six large finger-like devices are remotely controlled probe positioners used to obtain basic air flow measurements within a turbine. This is one of the techniques for obtaining scientific data vitally important to the design and development of the world's most powerful aircraft engines.

. . . in the field of INSTRUMENTATION

Among the many engineering problems relative to designing and developing today's tremendously powerful aircraft engines is the matter of accumulating data — much of it obtained from within the engines themselves — and recording it precisely. Such is the continuing assignment of those at Pratt & Whitney Aircraft who are working in the highly complex field of instrumentation.

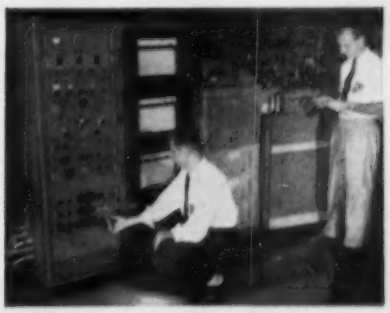
Pressure, temperature, air and fuel flow, vibration — these factors must be accurately measured at many significant points. In some cases, the measuring device employed must be associated with special data-recording equipment capable of converting readings to digital values which can, in turn, be stored on punch cards or magnetic tape for data processing.

Responsible for assembling this wealth of information so vital to the entire engineering team at Pratt & Whitney Aircraft is a special group of electronic, mechanical and aeronautical engineers and physicists. Projects embrace the entire field of instrumentation. Often involved is the need for providing unique measuring devices, transducers, recorders or data-handling equipment. Hot-wire anemometry plays an important role in the drama of instrumentation, as do various types of sonic orifice probes, high temperature strain gages, transistor amplifiers, and miniaturized tape recording equipment.

Instrumentation, of course, is only one part of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of combustion, materials problems, mechanical design and aerodynamics — spells out a gratifying future for many of today's engineering students.

Instrumentation engineer at Pratt & Whitney Aircraft is shown investigating modes of vibration in a blade of a single stage of a jet engine compressor.

Special-purpose probes designed and developed by P & W A engineers for sensing temperature, pressure and air flow direction at critical internal locations.



The "Plottomat", designed by P & W A instrumentation engineers, records pressure, temperature and air flow direction. It is typical of an expanding program in automatic data recording and handling.

Pratt & Whitney Aircraft operates a completely self-contained engineering facility in East Hartford, Connecticut, and is now building a similar facility in Palm Beach County, Florida. For further information about engineering careers at Pratt & Whitney Aircraft, write to Mr. F. W. Powers, Engineering Department.

World's foremost designer and builder of aircraft engines

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

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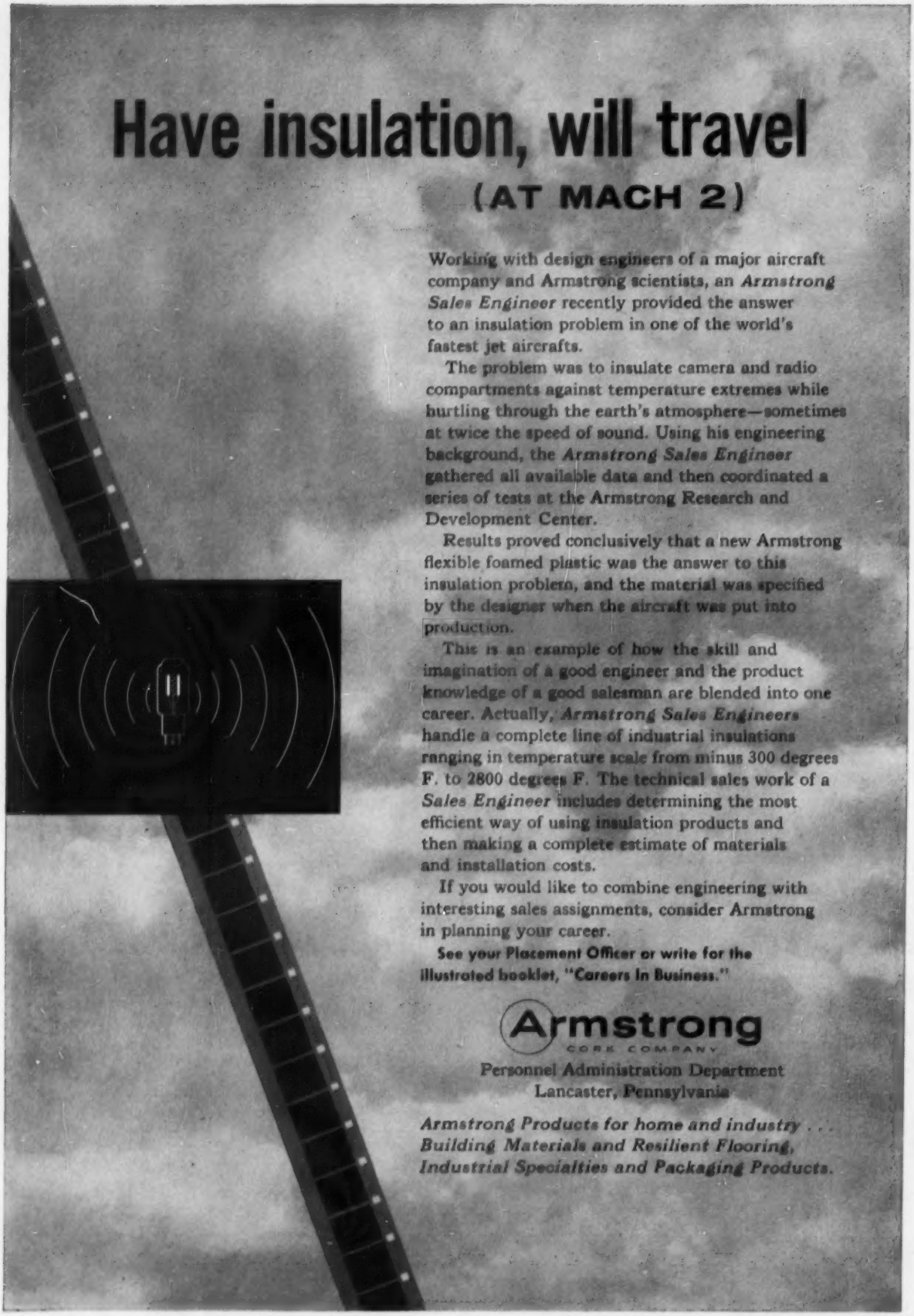
Have insulation, will travel
(AT MACH 2)



Working with design engineers of a major aircraft company and Armstrong scientists, an *Armstrong Sales Engineer* recently provided the answer to an insulation problem in one of the world's fastest jet aircrafts.

The problem was to insulate camera and radio compartments against temperature extremes while hurtling through the earth's atmosphere—sometimes at twice the speed of sound. Using his engineering background, the *Armstrong Sales Engineer* gathered all available data and then coordinated a series of tests at the Armstrong Research and Development Center.

Results proved conclusively that a new Armstrong flexible foamed plastic was the answer to this insulation problem, and the material was specified by the designer when the aircraft was put into production.

This is an example of how the skill and imagination of a good engineer and the product knowledge of a good salesman are blended into one career. Actually, *Armstrong Sales Engineers* handle a complete line of industrial insulations ranging in temperature scale from minus 300 degrees F. to 2800 degrees F. The technical sales work of a *Sales Engineer* includes determining the most efficient way of using insulation products and then making a complete estimate of materials and installation costs.

If you would like to combine engineering with interesting sales assignments, consider Armstrong in planning your career.

See your Placement Officer or write for the illustrated booklet, "Careers In Business."

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Armstrong Products for home and industry . . . Building Materials and Resilient Flooring, Industrial Specialties and Packaging Products.

When you graduate, do you want a

JOB?

Sure you want a job . . . but you want more than just a job. You want a job with opportunity, a job that offers a challenge. Union Carbide offers such jobs.

Jobs with opportunity for what? Advancement, for one thing. Union Carbide is introducing new products at the rate of one every fifteen days. Each new product opens up new avenues of advancement. Not only that; markets for our present products are expanding at an exciting rate too.

Jobs with what kind of challenge? Union Carbide has always operated on the frontiers of science. The challenges are the challenges of that frontier—the challenges of new ideas. Union Carbide is already among the largest U. S. producers of titanium—will tantalum be the next "wonder metal"? Union Carbide pioneered the two major plastics, vinyl and polyethylene—is another major break-through in the making? Challenging questions, and Union Carbide people are answering them.

Representatives of Divisions of Union Carbide Corporation, listed below, will be interviewing on many campuses. Check your placement director, or write to the Division representative. For general information, write to V. O. Davis, 30 East 42nd Street, New York 17, New York.

BAKELITE COMPANY Plastics, including polyethylene, epoxy, fluorothene, vinyl, phenolic, and polystyrene. J. C. Older, River Road, Bound Brook, N. J.

ELECTRO METALLURGICAL COMPANY Over 100 ferro-alloys and alloying metals; titanium, calcium carbide, acetylene. C. R. Keeney, 137—47th St., Niagara Falls, N. Y.

HAYNES STELLITE COMPANY Special alloys to resist heat, abrasion, and corrosion; cast and wrought. L. E. Denny, 725 South Lindsay Street, Kokomo, Ind.

LINDE COMPANY Industrial gases, metal-working and treating equipment, synthetic gems, molecular sieve adsorbents. P. I. Emch, 30 East 42nd Street, New York 17, N. Y.

NATIONAL CARBON COMPANY Industrial carbon and graphite products. PRESTONE anti-freeze, EVEREADY flashlights and batteries. S. W. Orne, P. O. Box 6087, Cleveland, Ohio.

SILICONES DIVISION Silicones for electrical insulation, release agents, water repellents, etc.; silicone rubber. P. I. Emch, 30 East 42nd Street, New York 17, N. Y.

UNION CARBIDE CHEMICALS COMPANY Synthetic organic chemicals, resins, and fibers from natural gas, petroleum, and coal. W. C. Heidenreich, 30 East 42nd St., New York 17, N. Y.

UNION CARBIDE INTERNATIONAL COMPANY Markets UNION CARBIDE products and operates plants overseas. C. C. Scharf, 30 East 42nd Street, New York 17, N. Y.

UNION CARBIDE NUCLEAR COMPANY Operates Atomic Energy Commission facilities at Oak Ridge, Tenn., and Paducah, Ky. W. V. Hamilton, P. O. Box "P", Oak Ridge, Tenn.

VISKING COMPANY A pioneer in packaging—producer of synthetic food casings and polyethylene film. Dr. A. L. Strand, 6733 West 65th Street, Chicago, Ill.

GENERAL OFFICES—NEW YORK Accounting, Electronic Data Processing, Operations, Research, Industrial Engineering, Purchasing. E. R. Brown, 30 East 42nd Street, New York 17, N. Y.

YAVNO

...on science and research

"In every field of science, advances in knowledge are forcing more and more specialization. As disciplines become narrower and their interactions harder to discern, communication among specialists becomes more difficult. At the same time, the relevance of political, economic, and social factors in the broad application of physics, chemistry, and mechanics to major practical problems is increasingly evident. Many such problems, unlike research at the frontiers of the specialties, are too broad in their implications and too complex in detail to be solved by any expert working alone. The research team, uniting the diverse skills of many specialists, and using the best mathematical tools — theoretical and computational — is probably the most successful means of discovering realistic, timely, and original solutions to important problems of public welfare and security."

— F. R. Collbohm, President

THE RAND CORPORATION, SANTA MONICA, CALIFORNIA

A nonprofit organization engaged in research on problems related to national security and the public interest

Research at Cornell—

ELECTRON SPIN RESONANCE

An electron is something too small to be seen or to be observed. Nevertheless, physicists have ingeniously devised means of observing phenomena of electrons. Professor Donald Holcomb of the Cornell Physics Department, assisted by Mr. Todd Sliker a research assistant, is undertaking the study of electron spin resonance in barium oxide crystals. It is hoped that this will provide valuable information about the properties of solids, particularly ionic crystals.

It is known that electrons spin and that they possess the primary unit of negative electrical charge. They also possess a magnetic moment because of their electrical nature. If the electrons are brought under the influence of a direct current magnetic field they will tend to align themselves within the field much as a group of iron filings will align themselves when a magnet is brought close. The electrons do not passively align themselves with the field due to the spin but instead undergo a precessional movement about the line of the field like small gyroscopes.

Effects Upon Application of Second Field

If now a second field is applied perpendicular to the first field, the second field being a linear alternating field, the electrons will undergo a precessional movement about the line of the second field.

If the frequency of the second field is equal to the precessional frequency of the electron spin, resonance will occur. The classic illustration of what is meant by resonance is the motion of a swing. If a person pushes the swing when the swing reaches the high point of its arc, the swing will move through greater and greater arcs. In other words, the person is pushing the swing at the same frequency that the swing possesses.

When the electrons resonate, they absorb energy from the source of the alternating magnetic field. In this experiment the electrons are the electrons trapped in the lattice defects of a crystal of barium oxide. The crystal structure of barium oxide is similar to that of sodium chloride—a planar view will reveal each barium ion surrounded by four oxygen ions, and each oxygen ion surrounded by four barium ions. There can be defects in this lattice in which the oxygen ion is missing. Electrons liberated by the thermal motion of the ions or from impurities in the crystal will be trapped in these defects.

If an even number of electrons is trapped, the electrons will pair up so that the magnetic moments are in opposite directions, thus cancelling. When the alternating linear field is applied there will be no apparent resonance effect. If there is an odd number of electrons the resonance effect will be noticeable.

Crystal Bombarded by Microwaves

The alternating linear field is composed of microwaves having the frequency of 9400 megacycles. The barium oxide crystal is supported in a cavity and subjected to both the direct magnetic field and the microwaves. Some energy is reflected from the cavity, and this reflected energy is partially dependent on conditions inside the cavity. If the electrons are trapped in odd numbers in the lattice defects, and the microwave frequency is at resonance, there will be a rise in the power reflected by the cavity. The measurement of the rise in reflected power is thus the indirect effect mentioned in paragraph one.

Preliminary results show that most crystals are such that no resonance effect is noticed. This indicated that an even number of electrons is trapped. From other considerations it is determined that the number trapped will be the lowest even number—two. But for some crystals the resonance effect is noticed—only one electron is trapped. Professor Holcomb will study the methods of producing each kind of crystal in order to find out just what determines the number of electrons trapped.

The experiment is being supported by grants from the Sloan Foundation and the Office of Naval Research. The primary purpose of the experiment is to further knowledge of ionic crystals. While no practical results are anticipated, studies on barium oxide may reveal methods of making better vacuum tubes, since the oxide is in wide use as the cathode material for the vacuum tube.

The Cornell Physics Department has studied barium oxide for about eight years. The program is directed by Professor Robert Sproull.

Assisting Professor Holcomb is Mr. Todd Sliker, research assistant in physics.

—William Krossner ChemE '61

A DU PONT JOB-FINDER CHART FOR

Here is a sampling of the kinds of engineers and scientists which Du Pont will employ this year with BS-MS training—and their fields of work. The chart is an easy way to match your own interests against job openings at Du Pont.

For example: If you are a mechanical engineer, run your finger across the "Mechanical Engineers" column. The code letters refer to the type of work (Research, Development, etc.). The departments of the Company are listed across the top. The column across the bottom indicates some of the locations where these departments have openings. Du Pont also has opportunities for other engineering and scientific specialties, but space does not permit a complete listing.

DEPARTMENT ▶	ENGINEERING	ELASTOMER CHEMICALS	ELECTRO-CHEMICALS	EXPLOSIVES	EXPLOSIVES, ATOMIC ENERGY DIVISION	FABRICS AND FINISHES
PRODUCTS	Designs and constructs major plant facilities. Conducts research and development, and provides engineering consultation in chemical and mechanical engineering, instrumentation, and materials technology.	Neoprene Rubber Chemicals Organic Isocyanates	Metallic Sodium Hydrogen Peroxide Vinyl Products Sodium Cyanide Chlorinated Solvents Nylon Intermediates	Sporting Powders Blasting Supplies Dynamite Polymer Intermediates	Nuclear Reactor Materials Heavy Water	Coated Fabrics Paints, Varnishes, Lacquers Synthetic Resin Finishes
CHEMICAL ENGINEERS	A, B, C	B	A, B, D, F	B, D	A, B	A, B, F
MECHANICAL ENGINEERS	A, B, C	B		E	A, B	
ELECTRICAL ENGINEERS	A, B, C			E		
METALLURGICAL ENGINEERS	A, B	A, B			A, B	
CHEMISTS			F			A, B, F
PHYSICISTS					A, B	
POSSIBLE INITIAL ASSIGNMENTS	Wilmington, Del., or Plant Locations	Beaumont, Tex. Louisville, Ky. Montague, Mich. Wilmington, Del.**	Memphis, Tenn. Niagara Falls, N.Y. Wilmington, Del.**	Gibbstown, N.J.	Aiken, S.C.*	Newburgh, N.Y. Parlin, N.J. Philadelphia, Pa.

PERSONALIZED INFORMATION—The kind of work you will do and the location of your first assignment depend on your qualifications and the openings available. Since the above chart was prepared, some of the openings listed may have been filled or new jobs may have been added to the list. For up-to-the-minute information about possible jobs for you, see the Du Pont representative when he visits your campus.

WATCH THE DU PONT "SHOW OF THE MONTH" ON TELEVISION

BS-MS ENGINEERS AND SCIENTISTS

A Research
B Development
C Design
D Production
E Plant Engineering
F Sales

FILM	GRASSELLI CHEMICALS	ORGANIC CHEMICALS	PHOTO PRODUCTS	PIGMENTS	POLYCHEMICALS	TEXTILE FIBERS
Cellophane Sponge Yarn Mylar® Polyester Film Cel-o-seal® Bands	Acids and Heavy Chemicals Biological and Agricultural Chemicals	Dyes Petroleum Chemicals Tetraethyl Lead Fluorinated Hydrocarbons	Photographic and X-Ray Film Photographic Papers Processing Chemicals	Titanium Pigment Pigment Colors Titanium Metal Hyperpure Silicon	Ammonia Antifreezes Urea Products Plastics Nylon Intermediates	Nylon Dacron® Polyester Fiber Orlon® Acrylic Fiber Rayon
A, B, D, F	A, B, D	A, B, F	A, B, D, F	A, B, F	A, B, D, F	A, B, D
A, B, D, E		A, B, F	A, B, E, F	A, B	A, B, D, F	A, B, D, E
B, D, E, F			E		A, B, D, F	B, D, E
		A, B, F	A, F	F	A, B, D, F	A, B, D
			A		A, B	A, B
Buffalo, N.Y. Circleville, O. Clinton, Ia. Old Hickory, Tenn. Richmond, Va. Wilmington, Del.**	Cleveland, O. East Chicago, Ind. Houston, Tex. Linden, N.J. Wilmington, Del.**	Deepwater, N.J. Wilmington, Del.**	Parlin, N.J. Rochester, N.Y.	Edge Moor, Del. Newport, Del. New Johnsonville, Tenn. Wilmington, Del.**	Charleston, W. Va. Orange, Tex. Parkersburg, W. Va. Victoria, Tex. Wilmington, Del.**	Camden, S.C. Chattanooga, Tenn. Kinston, N.C. Martinsville, Va. Old Hickory, Tenn. Richmond, Va. Seaford, Del. Waynesboro, Va. Wilmington, Del.**

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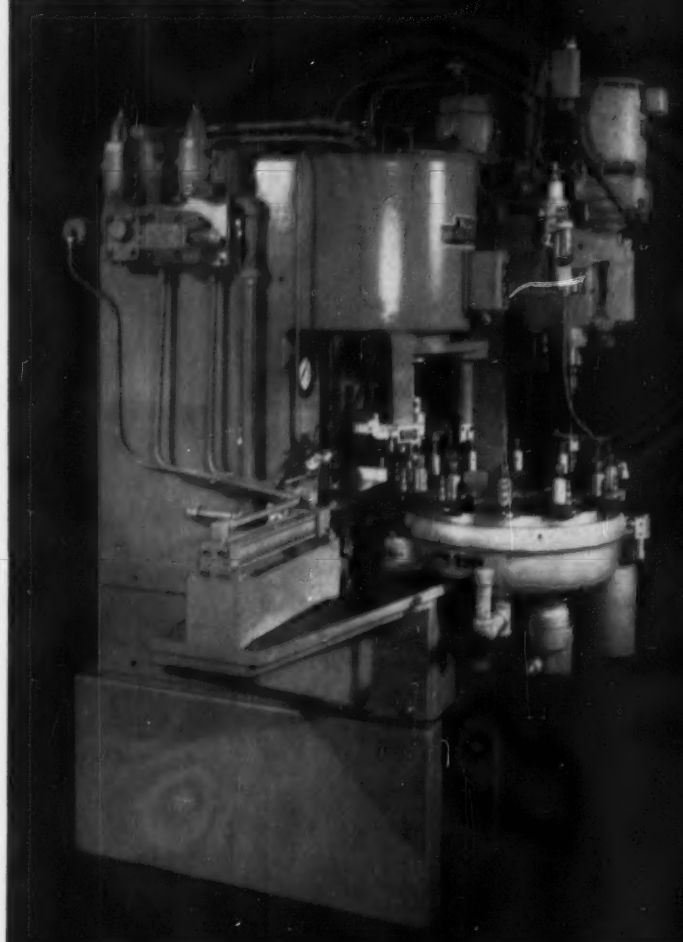
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

HYDRAULICS IN YOUR FUTURE



Streamlining production triples output

...another example of DENISON'S hydraulic ingenuity

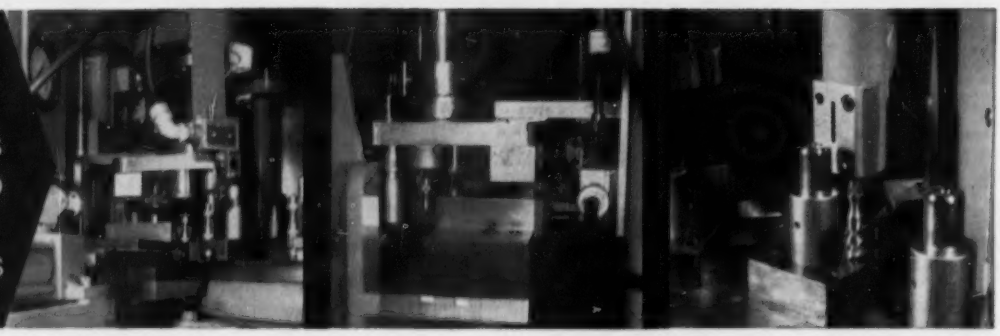
A manufacturer of home appliances boosted output, improved quality and reduced costs by streamlining production with Denison's hydraulic Multipress.

In this case, a special 8-ton Multipress, equipped with a 12-station hydraulic index table, performs seven individual jobs on beater spindles for food mixers with only one manual operation . . . loading of the parts. Once the cycle-start button is pressed, the spindles advance step-by-step until finished. These automated methods tripled output, assured accuracy of finished product.

Labor savings *alone* more than equaled the investment in the special machinery in less than a year. Savings on tooling, and in reduced scrap, were an added bonus.

This interesting case is typical of the ways industry has called on hydraulic power, and on Denison, to improve production methods. Find out how hydraulics fit into *your* future. Write Denison Engineering Division, American Brake Shoe Co., 1218 Dublin Rd., Columbus 16, Ohio.

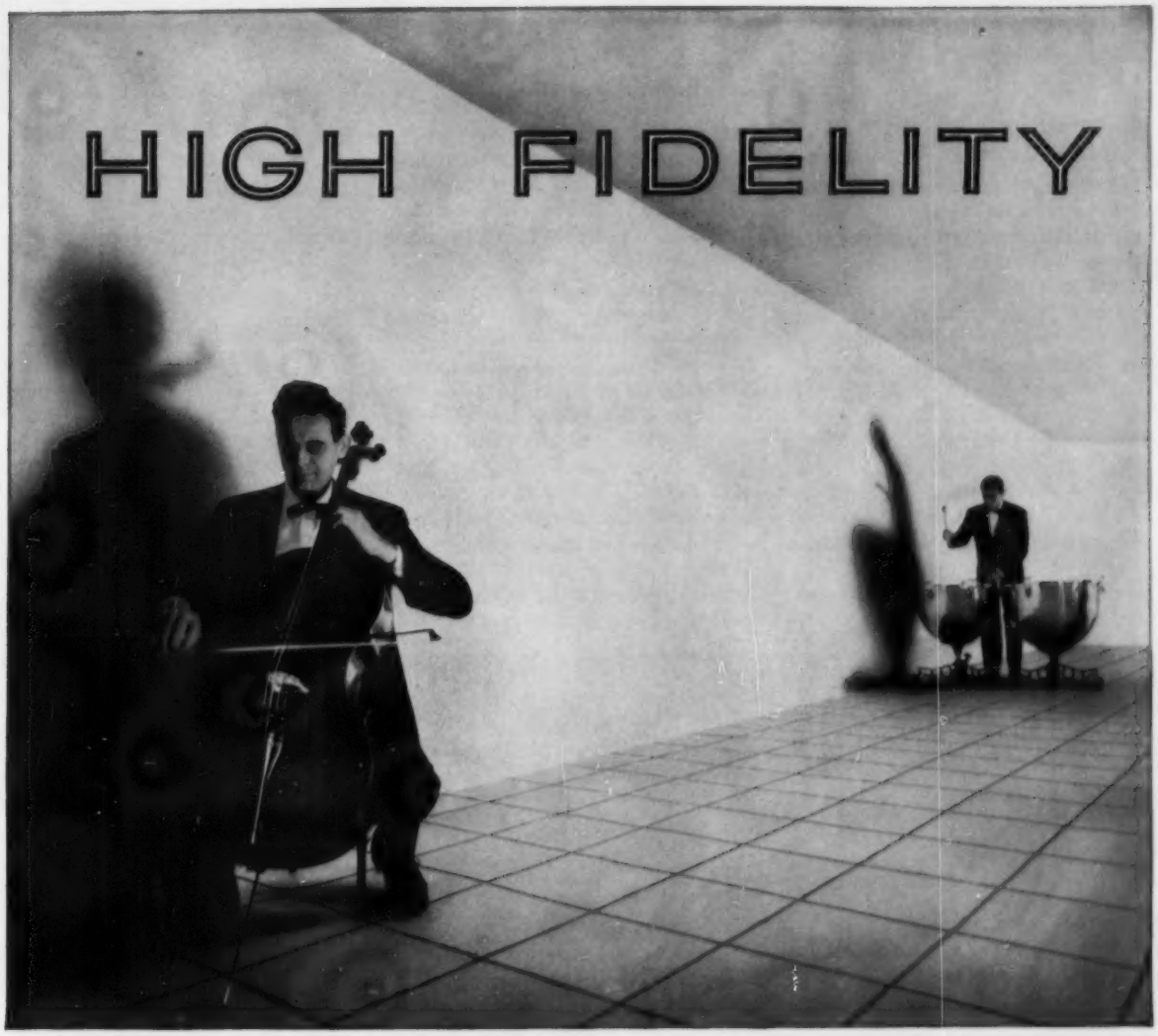
THREE OF SEVEN OPERATIONS PERFORMED HERE BY MULTIPRESS



Shearing Four Slots . . . Trimming Chips . . . Pressing Hopper-Fed Sleeve

Look to **DENISON** *for leadership in hydraulic development*

DENISON HydrOILics



How RCA brings a richer, wider range of musical sound to your home

Before high fidelity, the sound of recorded music was limited—much as piano music would be if you could hear only the notes played on the center of the keyboard. No rich bass notes, no keen, vibrant highs.

RCA achievements in the science of sound and acoustics changed all that. Today, with RCA Victor records and high fidelity "Victrolas," the *full range* of sound is reproduced so faithfully that you can enjoy music almost as though you were *there*.

And now, Stereophonic Sound! A new and dramatic dimension in recorded music is also yours to enjoy on RCA high fidelity instruments. Stereophonic units can be added to most "Victrola"* Hi-Fi systems. any time you choose.

In this, as in almost every area of electronic progress in home entertainment, defense and industry, the leadership of RCA serves you. RCA *means* electronics at its best!

WHERE TO, MR. ENGINEER?

RCA offers careers in research, development, design, and manufacturing for engineers with Bachelor or advanced degrees in E.E., M.E. or Physics. For full information, write to: Mr. Robert Haklisch, Manager, College Relations, Radio Corporation of America, Camden 2, N. J.

RADIO CORPORATION OF AMERICA

TECHNIBRIEFS

METALS FLOAT IN SPACE IN NEW PURIFICATION PROCESS

Man's newest "wonder" metals are now being investigated by heating them thousands of degrees above white heat, while they float, freely suspended in space. Called levitation melting, this unique and versatile technique was invented by Westinghouse research scientists and brought to its present state of development by the combined efforts of scientists at the Westinghouse Research Laboratories and the University of British Columbia.

Levitation melting is used to prepare highly purified laboratory-scale ingots of niobium, zirconium, titanium, molybdenum and dozens of alloys. Because they melt at very high temperatures, and are extremely active chemically at such temperatures, these metals and alloys are difficult to prepare with equal purity by any conventional method.

In levitation melting, compressed metal powder is placed inside a copper coil which carries a high-frequency current of electricity. Reversing its direction nearly a million times a second, the electric current generates a field of force which floats the metal charge inside the coil. At the same time, it converts the metal into a white-hot molten mass in a matter of seconds. Temperatures of 4500 to 5000 degrees Fahrenheit are achieved in half a minute or less, melting all but the most stubborn of metals.

At white heat, metals such as niobium and titanium are among the most active chemicals known. They react chemically with any known vessel in which they are melted. The traces of impurities they pick up cannot be tolerated in research on the pure metal.

Levitation melting eliminates this problem entirely, the Westinghouse scientists point out. No containing vessel is required, since the molten metal floats freely in space, confined only within itself. The whole process is carried out inside a sealed vessel containing an inert gas such as helium or argon, thereby protecting the pure metal from contamination by the air.

Westinghouse Research Laboratories

Inside this sealed glass vessel containing helium and argon, metals are purified for laboratory use.

AIR STUCTURE FOUND TO BE ALTERED BY GUIDED MISSILES

"Tomorrow's guided missiles and airplanes are going to fly through a totally different 'air' than they fly through today," a Cornell Aeronautical Laboratory physicist reports.

As our supersonic aircraft fly faster and faster they will soon penetrate the hypersonic speed range, that is, they will travel at speeds higher than five times that of sound. The behavior of air during flight at these speeds is the subject of extensive research at the Laboratory, Dr. Joseph G. Logan writes in the spring issue of Cornell Lab's publication, *Research Trends*.

When a missile nose or airplane wing cleaves the air at hypersonic speeds, the shock waves formed produce temperatures between 2000°F and 10,000°F. When the air next to the aircraft surfaces gets this hot, the oxygen and nitrogen molecules of the air change their behavior radically. The normally well-behaved molecules then collide, vibrate, break up, shed some electrons, and form entirely new components—like nitric oxide.

"The introduction of these new components alters the thermodynamic properties of the air, and forces the aeronautical engineer to discard many of the rules he has lived by for so long," writes Dr. Logan.

Westinghouse Research Laboratories

This close-up view demonstrates levitation melting.

The specific heat and molecular weight of the air under these conditions will be markedly different from those the aircraft designer knew in the past. The distribution of air pressures will no longer obey the laws the designer has applied so many times before. These are just a few of the problems cited by researchers at the Buffalo, N.Y. Laboratory.

An important problem being investigated at CAL today deals with the actual state of air in hypersonic shock tunnels, according to Dr. Logan. These facilities are capable of generating shock waves up to Mach 22, with corresponding increases in temperature. The Lab's research is already proving invaluable in the design of more advanced facilities, Dr. Logan adds.

"Interest in these problems of fluid flow has triggered many new fields of research," Dr. Logan points out. It has led to studies of the kinetics of the formation of nitric oxide, and has stimulated development of a special shock tube to investigate chemical reactions at high temperatures, he reports.

CAL is a non-profit organization engaged in research and development in the areonautical sciences and related fields.

● EXTREMELY SMALL PERMANENT MAGNETS

Permanent magnets as small in diameter as a human hair have been made from Cunife at the National Bureau of Standards. Cunife is an alloy of approximately 60 percent copper, 20 percent nickel, and 20 percent iron with an unusual combination of magnetic and mechanical properties. For example, Cunife—instead of requiring casting or sintering into a desired shape like most highly coercive magnet materials—can be cold drawn. This ductility suggested its use for very small magnets. In an effort to determine its suitability for this application, I. L. Cooter and R. E. Mundy of the Bureau's magnetic measurement laboratory carried out an investigation of Cunife's magnetic properties when cold drawn into fine wires.

Several investigators have reported on the magnetic properties of Cunife wire and on the effects of cold working and subsequent heat treatment. Their results have shown that even if the material is cold worked to the point at which the magnetic properties are adversely affected, the initial magnetic properties may be recovered or improved by a simple heat treatment or baking. These reports, however, pertained only to the larger wire sizes. No data were available on the magnetic properties of Cunife drawn to wire a few thousandths of an inch in diameter.

The Bureau's evaluation entailed cold drawing Cunife to a diameter at which its magnetic properties change and then observing the effect of various heating procedures on the restoration of magnetic properties. Cunife is available commercially in the form of wire with a diameter of 0.025 in. This wire was first cold drawn to 0.020 in. through carboloy dies and further reduced to 0.005 in. through diamond dies. At various stages of reduction samples were cut from the coil of wire for later measurements.

● STRANGE CRYSTAL GROWTH MAY EXPLAIN STEEL FAILURE, WESTINGHOUSE REVEALS

Crystals, which grow as delicate plates from the surface of stainless steel, may explain, for the first time, a destructive failure of the metal known as "stress-corrosion cracking."

This new theory was revealed by an international authority on corrosion, Dr. Earl A. Gulbransen, advisory chemist at the Westinghouse Research Laboratories in Pittsburgh, Pa. Dr. Gulbransen spoke before the Second World Metallurgical Congress, at the International Amphitheatre, Chicago, under sponsorship of the American Society for Metals.

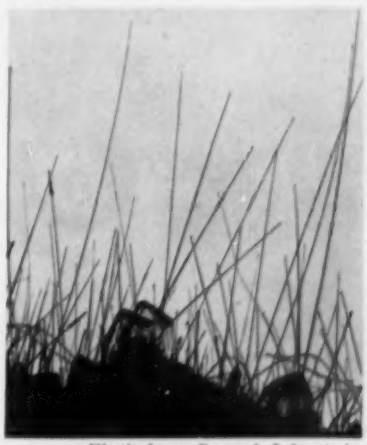
Stress-corrosion cracking can occur in metal structures which are chemically corroded while under an internal or applied stress, such as a pull or twist. It can cause complete failure of the structure.

Stress-corrosion cracking can be triggered even by such mildly corrosive substances as steam or human perspiration; and it occurs in objects subjected only to the internal stresses left in them during their manufacture. Stainless steel pipes, turbine blades—even coffee urns and cooking vessels can fail by stress-corrosion cracking.

Dr. Gulbransen described the newly discovered crystals as "submicroscopic platelets of chromium oxide." They form on strongly stressed stainless steel specimens which are exposed to corroding atmospheres containing traces of negatively charged chlorine atoms —more properly referred to as chloride ions.

"We believe that this unique crystal growth has important bearing on the whole general problem of stress corrosion," Dr. Gulbransen said, "for it has suggested to us a mechanism on the atomic scale to explain such corrosion.

"We think that this growth of platelets off the surface of the steel could lead to a chemical cutting of the metal. Minute crevices, therefore, might grow downward



Westinghouse Research Laboratories

These oxide whiskers grow on the surface of stainless steel when it is corroded at high temperatures by pure water vapor and oxygen.

Westinghouse Research Laboratories

Delicate sheets of crystal erupt from the surface of stainless steel in corrosion studies.

into the metal surface as the platelets thrust themselves above it. This, we believe, may lead to concentration of stress at the base of the crevices and eventually to failure of the metal."

For some time scientists have known that the chloride ion is a major factor in producing stress-corrosion cracking of stainless steel. It would now appear that chloride ions could stimulate the growth of these unique, plate-like crystals on a strongly stressed metal, which growth might result in cracking and the ultimate failure of the steel.

"Corrosion in all its forms is a major national problem, costing American industry an estimated $5,500,000,000 annually in replacement costs alone," Dr. Gulbransen added. "Our experiments, we think, are typical of a new approach to this whole problem—an approach which seeks a better understanding of the fundamental mechanisms involved in corrosion.

NEW INSTRUMENT TO PROVIDE FOR CLOSER STUDY OF CELL

Scientists can now explode biological cell walls without disturbing the nucleus, making possible closer study of the cell center, thanks to a new all stainless steel instrument.

In theory, the instrument's operation is like driving a steam roller over an egg, and still keeping the yolk intact for a closer examination.

This almost impossible task is being done with a French Pressure Cell made by the American Instrument Company of Silver Spring, Md. Allegheny Ludlum Steel Corporation supplies the stainless steel for the new study tool.

The instrument is almost simplicity itself. The body of the French Pressure Cell is six inches long, and three inches in diameter. A one-inch diameter hole drilled in the center is fitted with a piston.

Blood cells, unicellular organisms, special animal tissue, or cellular structure of any living tissue or serum which are to be studied are put into the cylinder. When the specified amount of a given sample is in the instrument, air is removed. The cell is placed under a hydraulic press, and pressures up to 20,000 psi are applied and suddenly released.

The sample's cellular walls are exploded, but the nucleus is unaffected for examination of its biochemical components.

The pressure cell is also used for extraction of virus and virus related materials in the immunological studies being conducted by the National Institutes of Health, one important example of which is the current study on tuberculosis.

A sample is obtained through a pressure release valve, with constant pressure being maintained on the equipment.

Allegheny Ludlum Steel Corp.

The French Pressure Cell explodes walls while keeping nucleus intact for later study.

AUTOMOBILE MANUFACTURERS TO END EMPHASIS ON SPEED

The Board of Directors of the Automobile Manufacturers Association unanimously recommended to member companies that they take no part in automobile racing or other competitive events involving tests of speed and that they refrain from suggesting speed in passenger car advertising or publicity.

The Board voiced the desire of automobile manufacturers to "encourage owners and drivers to evaluate passenger cars in terms of useful power and ability to afford safe, reliable and comfortable transportation, rather than in terms of capacity for speed."

All volume producers of passenger automobiles in the U. S. are represented in the Automobile Manufacturers Association.

The resolution stated that the Association and the members of the Board "share the public interest in increasing the safety of highway travel."

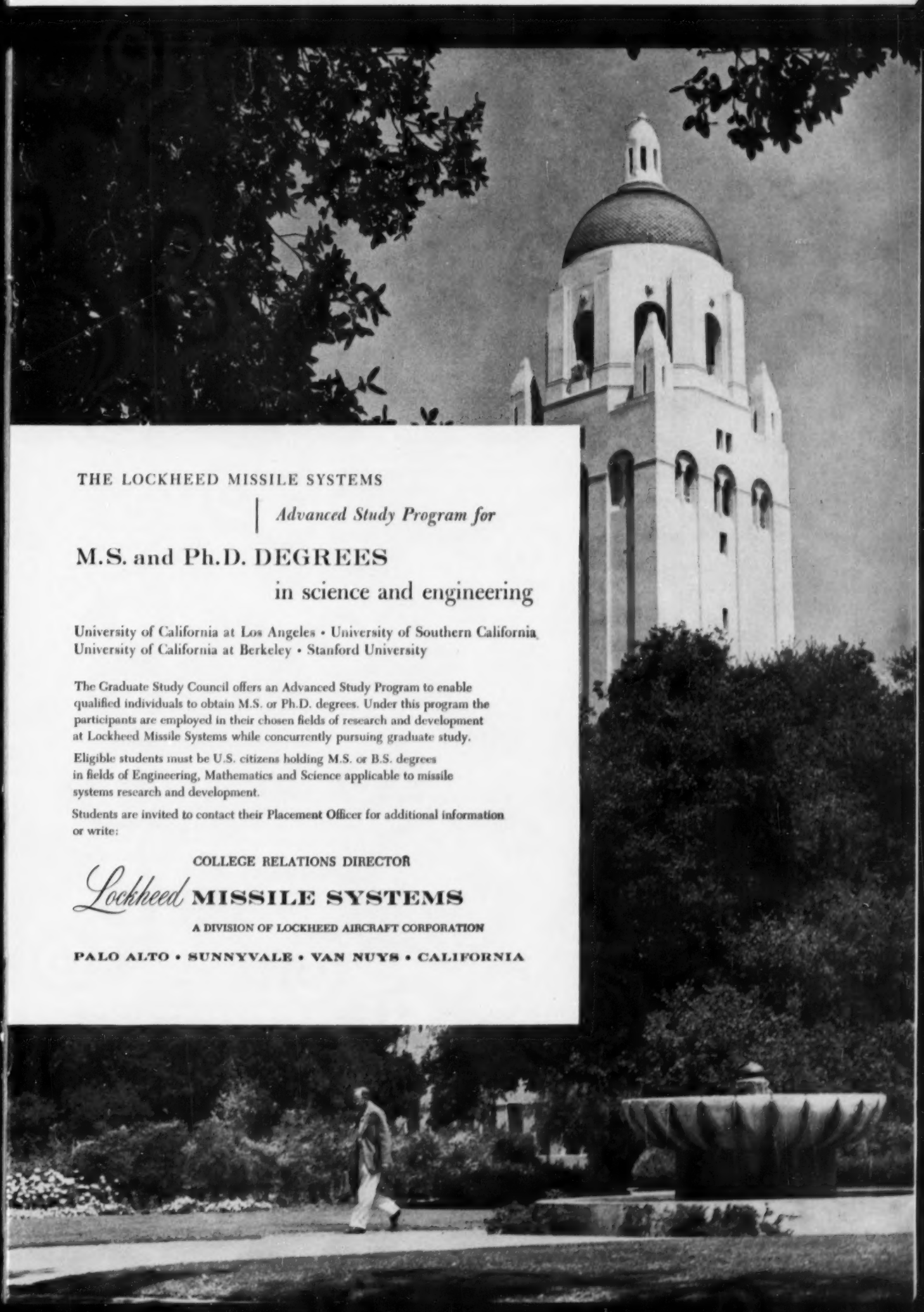
"The manufacturers of automobiles," the resolution read, "have directed their efforts for many years toward developing and maintaining the performance characteristics of vehicles at levels consistent with highway conditions and the requirements of the using public."

Manufacturers can best serve the public by continuing these efforts, the document stated, "utilizing research and testing facilities, laboratories and engineering proving grounds to conduct tests under controlled and scientific conditions and standards."

The resolution recommended that member car manufacturers:

1. Not participate in any public, competitive test of passenger cars involving or suggesting racing or speed, including acceleration tests.
2. Not encourage or assist employees, dealers or others, or furnish financial, engineering, manufacturing, advertising or public relations assistance in connection with any such event, directly or indirectly.
3. Not supply "pace cars" or "official cars" in connection with any such event.
4. Not advertise or publicize any such event or the results thereof, or assist and encourage others to do so.

(Continued on Page 63)



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COLLEGE NEWS

ENGINEERING ETHICS TOPIC OF TALK HELD DURING CCR

"Honesty, justice and courtesy constitute the foundation of engineering ethics," stated Col. Carey Brown in his talk on "The Engineer and Ethics" before students in Phillips Hall during Cornell's Campus Conference on Religion. The talk sponsored by the Undergraduate Engineering Council was one of many made by prominent religious and civic leaders during the conference held from November 17th to the 24th.

Colonel Brown, a West Point graduate and former Manager of the engineering service section of Eastman Kodak, stressed that while morality and religion are assumed to be the same, one can be moral but not religious.

"The man who is moral but self centered is not truly religious. Thus morality is only an ingredient of religion." He continued, saying that a truly professional engineer must be ready and willing to apply his knowledge for the betterment of mankind rather than for his own personal gain.

In comparing the ethics of today with those of fifty years ago Col. Brown stated that, although many major contracts were made and kept by a handshake fifty years ago as compared to the involved legal documents of today's agreements, today's ethics aren't necessarily lower. This is so because of the complex tax considerations of today's corporations, making contracts absolutely necessary.

Similarily, he felt that the severe competition between companies that exists today doesn't lower professional ethics to a great degree. Col. Brown did feel, however, that unfair engineering recruiting practices are definitely a violation of engineering ethics. He noted such practices as engineers visiting various plants of different companies in the same general area and then filing expense accounts with all the companies for the full amount of the trip. In many cases this practice was encouraged by the company recruiters.

Concluding, Col. Brown read the Civil Engineers Code of Ethics to illustrate what should be the proper conduct of all engineers. After the talk Col. Brown answered questions from the audience.

N.Y. TELEPHONE ENGINEERS STUDY AT EE SCHOOL

Transmission engineers of the New York Telephone Company are participating in an intensive three week study program this term at Cornell's School of Electrical Engineering. The study program is designed to acquaint the engineers with new problems in transmission engineering brought about by television, telemetering, automatic remote control equipment, mobile communication and long distance telephone dialing.

Each three week study group consists of twenty engineers of varied experience and background with New York Telephone Company. By the end of the program it is expected that a total of 150 engineers will have participated. Those engineers who qualify will return for two more advanced three week programs during the next year.

Instruction is being given by four former Bell System engineers who have joined the Faculty of the E.E. School. In the advanced phases instruction will be given by a seven man group of the Electrical Engineering School. It is hoped that the many years of experience possessed by these men will be of great value in instructing those participating in the program.

While here the "students" are living in Sheldon Court and studying at Phillips Hall.

The program coordinator is Professor Howard G. Smith '30 of the EE School.

NOTED SCIENTIST TO GIVE CHEMISTRY LECTURES HERE

Ronald P. Bell, University reader in physical chemistry and fellow of Balliol College, Oxford, England, will deliver the Baker Lectures in Chemistry at Cornell University beginning in February, 1958. He will speak on "The Proton in Chemistry."

Recent research by Professor Bell has dealt chiefly with acids and bases in water and other solvents, particularly the catalysis of chemicals by acids and bases.

He is the author of numerous scientific publications including a book entitled "Acid-Base Catalysis."

Professor Bell was educated at Maidenhead County Boys School and Balliol College, Oxford, and engaged in research for four years at the University of Copenhagen. In 1932 he returned to Balliol College as Fellow and Tutor in Chemistry. He was made a University lecturer in 1938 and University reader in physical chemistry in 1955.

Professor Bell was made a Fellow of the Royal Society of London in 1944. He has also been a member and vice president of the Chemical Society Council, and a member and vice president of the Faraday Society Council.

Professor Bell was a visiting professor at Northwestern University in 1954.

The Baker Lectureship was endowed in 1919 by the late George F. Baker, banker, philanthropist and former Cornell trustee. Mr. Baker also gave Cornell funds for Baker Laboratory of Chemistry and for Baker Dormitory for Men.

WESTINGHOUSE CONSTRUCTS MICROWAVE LAB AT ITHACA

Westinghouse Electric Corporation is setting up a temporary Microwave Research Laboratory in Ithaca. Although the lab will be completely separate from Cornell, close co-operation between the University Faculty and the staff of the research lab is planned.

Professors Eastman and Dalman of the E.E. School have done much of the ground work for an informal agreement whereby the top men

from the lab would visit Cornell periodically to give talks and attend graduate seminars.

While the temporary lab is under construction, the Westinghouse scientists are expected to have access to university equipment. Later, an informal agreement will probably be in operation whereby Cornell professors will also have access to the Westinghouse equipment.

It is also expected that Westinghouse will send some of its more promising young men to Ithaca to take graduate work at Cornell while working at the research lab.

Ithaca was chosen as the site of the lab over several other possible locations because of its proximity to Cornell, where excellent consultation is readily available, and to Elmira, where Westinghouse has a large microwave tube plant, where any new theoretical developments will be produced.

The temporary laboratory, located on N. Aurora St., will not be completed for at least another year, although the offices are operating now. If things go smoothly in the next few years, Westinghouse may build a larger, permanent lab, housed in its own building and employing over 40 top-notch research scientists.

DEAN HOLLISTER APPOINTED TO FEDERAL CONSULTANT POST

S. C. Hollister, Dean of the College of Engineering at Cornell University, has been appointed to membership on a special staff of technical consultants to the Committee on Merchant Marine and Fisheries in Washington, D.C. The committee is concerned with the need for providing more transit facilities between the Atlantic and Pacific Oceans.

Representative Herbert C. Bonner (D-N.C.), chairman of the committee, announced the appointment of the 6-man staff which consists of consulting engineers who have specialized in large engineering projects.

Dean Hollister has served as a member of the second Hoover Commission and was a member of the Engineering Manpower Commission. He has been largely responsible for the development of the new engineering quadrangle at Cornell and the broadening of the engineering curriculum to a five-year course.

In announcing the appointment of the group of technical consultants, Chairman Bonner said, "In view of the present world situation, with particular reference to lessons to be learned from the Suez Canal closure and the increasing burden of traffic on the facilities of the Panama Canal, I feel that it is the urgent responsibility of the Merchant Marine and Fisheries Committee to be fully informed concerning the adequacy of the existing Canal and the need for additional facilities either in the Canal Zone or at alternate locations in the Central American Isthmus."

WIEGANDT ATTENDS MEETING ON CONVERSION OF SEA WATER

Herbert F. Wiegandt, professor of chemical engineering at Cornell University's School of Chemical and Metallurgical Engineering, has recently participated in an international symposium on the conversion of sea water.

The conference, sponsored by the National Academy of Sciences—National Research Council, was held in Washington, D.C. on November 4, 5 and 6. Professor Wiegandt's paper was titled "Direct Freezing—Theory and Research."

"An inexpensive method for converting sea water to fresh water would be of prime importance economically," Professor Wiegandt says. "Many fuel-rich areas in the Middle East and other arid areas which do not have access to salt-free water would find it possible to improve their entire economic structure if a cheap method for conversion were developed. Progressively more serious problems of water shortage must also be faced in the United States."

Professor Wiegandt's paper is based upon research on continuous crystallization which he has conducted at Cornell since 1953. For making fresh water from the sea the principle of the heat pump, now being used in some year-round air conditioning systems, is applied to the freezing and melting of ice. A separation tower using reflux is the heart of the purification step.

The conference is being given in conjunction with the U.S. Department of the Interior.

Professor Wiegandt was educated at Purdue University. He received the B.S. degree in chemical engineering in 1938, the M.S. in 1939 and the Ph.D. in 1941.

URANIUM PRODUCTION TOPIC OF TALK AT A.I.CHEM.E. MEETING

The last meeting of the American Institute of Chemical Engineers featured a discussion of the chemical engineering aspects of uranium production and a film on the peacetime uses of atomic energy.

The guest speaker was Mr. R. M. Edwards, manager of the Process Development Department of the Uranium Division of the Mallinckrodt Chemical Works.

The meeting was held on December 13, 1957 at eight o'clock in lecture room B of Olin Hall. There were refreshments and an informal discussion following the meeting.

PROFESSOR CONTACTS ITHACA FROM BASE IN ANTARCTICA

Carl W. Gartlein of Cornell University, who is at present in Little America participating in aurora research as part of the International Geophysical Year, has twice made contact with his family in Ithaca by means of short wave radio.

Professor Gartlein, physicist and director of the IGY Auroral Data Center for visual observations for the western hemisphere, is inspecting aurora apparatus installed at the Little America base.

"We are collecting barrels of data," Professor Gartlein said in a radio message Thursday night. He is part of a group of "summer personnel" stationed at the remote polar base.

Professor Gartlein expects to remain in Little America until the end of November. If the ice remains firm enough for airplane takeoff, he will proceed by plane to McMurdo base, at the edge of the continent, and from there to Christchurch, New Zealand. If the ice melts, he will be forced to take a slower route by boat.

He plans to return to Ithaca by the middle of December.

Mrs. Gartlein is maintaining Professor Gartlein's aurora observatory while he is in Little America.

(Continued on Page 69)

LOOK WHO'S IN THE DRIVER'S SEAT...

...but are you really?

and equally important, are you going to get somewhere?

Perhaps you have heard some classmate say, almost complacently, "Times have changed."

With many branches of industry today openly competing for good science and engineering graduates, who can blame the young graduate-to-be for feeling supremely confident. You know you can get a job, know that salaries are high and are fully aware that men with technical backgrounds are moving up to administrative positions in ever-increasing numbers.

Nevertheless, in many respects, times have not changed at all. That "first job" is every bit as important today as it was five, ten, twenty years ago. Starting salaries remain only one of many factors to be considered. And a man's future is still necessarily linked to the future of the company for which he works. Moreover, a thoughtful examination of such matters as potential growth, challenge, advancement policy, facilities, degree of self-direction, permanence, benefits and the like often indicates that real opportunity *still* does not grow on trees.

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Book Review:

Mechanisms and Dynamics of Machinery

by

H. H. Mabie and F. W. Ocvirk

. . . Reviewed by A. H. Church

"MECHANISMS AND DYNAMICS OF MACHINERY" by H. H. Mabie and F. W. Ocvirk, published by John Wiley & Sons, 1957.

This text gives a very able presentation of what this reviewer feels is an awkward combination of subjects. Mechanisms is generally regarded as the application of kinematics of machinery, and therefore tends to be descriptive rather than analytical. To cover such subjects as linkages, cams and gears before studying the kinematics of machinery which is a chapter in the middle of the book, throws considerable strain on the authors and the teachers of the course, and in turn reduces the course efficiency which is so needed these days.

In spite of this difficulty the authors have been able to introduce advanced material of an analytical nature in the early chapters. As examples, there are discussions of analytical cam design, minimum radius of curvature, and pressure angle determination in the cam chapter; an extended discussion of the minimum number of teeth to avoid interference of spur gears; a chapter on non-standard gear teeth; and so on.

One chapter contains an excellent introduction to the design of computing mechanisms. This should prove to be most thought-provoking and stimulating to students.

The problem of the synthesis of linkages is quite difficult and it might better be left for an advanced course. Nine pages seem hardly adequate in any case for a subject of this complexity.

Force analyses of machinery is very extensively treated and includes the external forces handled by a machine as well as the internally developed inertia forces. Also included in this discussion is a treatment of crank effort diagrams. The application of force analysis principles to various specific machines is developed and this should be helpful to the student.

A chapter on balancing adequately covers the usual cases for rigid bodies and balancing machines plus the balancing of multicylinder in-line and angle units.

The concluding chapter on machinery vibration gives an excellent introduction for rectilinear and torsional systems having one and many degrees of freedom. Also included here is the procedure to determine equivalent dynamic systems.

At the ends of the chapters are a great number of problems. Many of these appear to require some original thought on the part of the student rather than straight substitution in formulas. The type and number of these problems is a definite asset to the use of the book as a text.

In any text of this nature one can think of many additional topics that might be included if space and time permitted, and it becomes a matter of judgement and balance to decide what should be retained or omitted. However, an undergraduate student who has covered the material in this book has a solid background to handle advanced problems in the field, and the authors are to be congratulated on preparing a very readable text.

A. H. Church

THE AUTHORS

Professors Fred W. Ocvirk received his BS from Wayne State College in 1938 and his MS from the University of Illinois in 1940. He joined the staff of the ME School at Cornell soon afterwards as an instructor. Today he is an associate professor teaching the mechanical engineering courses of Mechanisms and Dynamics. At present he is engaged in a project to determine the effect of high speed on journal bearings. He is a member of ASME, ASLE, ASEE and the engineering honoraries Tau Beta Pi and Pi Tau Sigma.

Professor Hamilton H. Mabie received his BME from the University of Rochester in 1940, his MS from Cornell in 1943 and his Ph.D. from Penn State in 1954. He joined the staff of the ME school in 1941 as an instructor and now holds the position of associate professor. Pro-

(Continued on Page 69)

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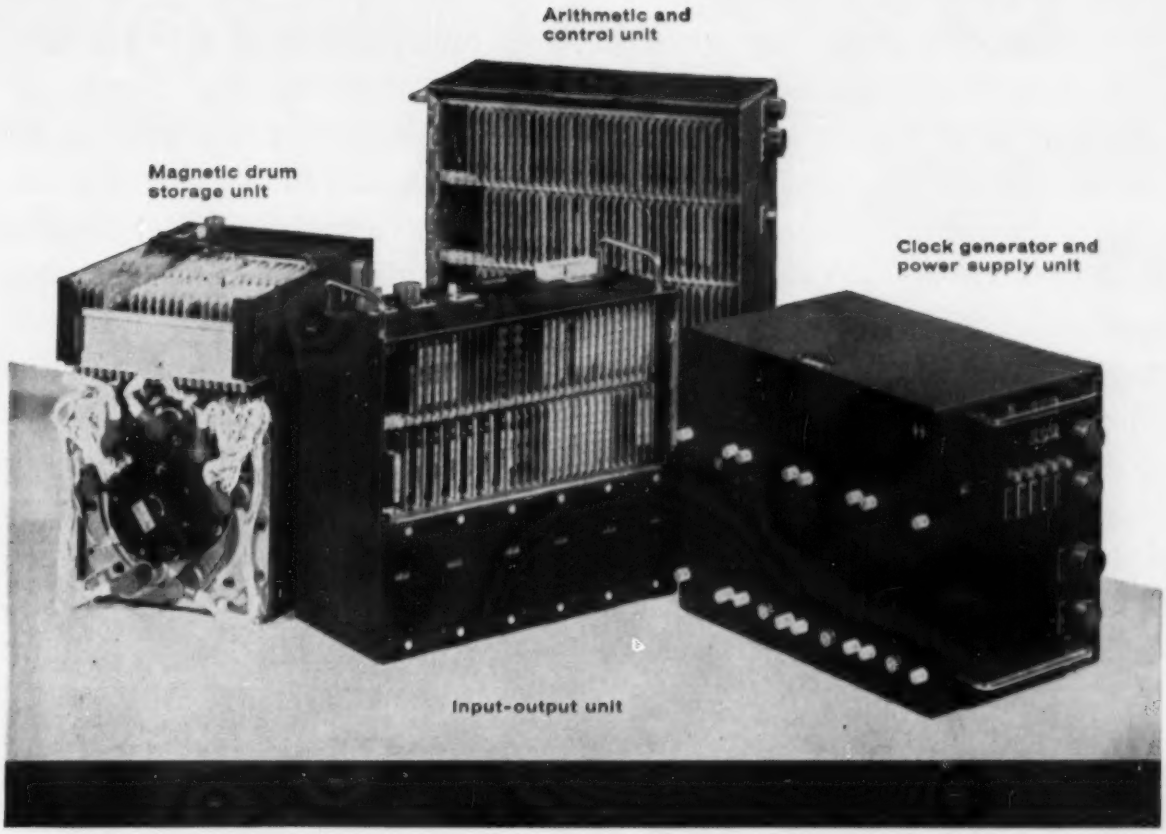

The Importance of
DIGITAL TECHNIQUES

Digital techniques constitute one of the important developments which have made possible the recent advances in computers and related equipment for computation, data processing, and industrial and military electronic control.

Digital computers for scientific computation range from small specialized units costing a few thousand dollars, to large general-purpose computers costing over a million dollars. One of these large computers is a part of the Ramo-Wooldridge Computing Center, and a second such unit is being installed early this year.

Electronic data processing for business and industry is rapidly growing based on earlier developments in electronic computers. Data processors have much in common with computers, including the utilization of digital techniques. A closely related field is that of industrial process control. To meet the needs in this field, Ramo-Wooldridge has recently put on the market the RW-300 Digital Control Computer.

The use of digital techniques in military control systems is an accomplished fact. Modern interceptor aircraft, for example, use digital fire control systems. A number of Ramo-Wooldridge scientists and engineers have pioneered in this field, and the photograph above shows the RW-30 Airborne Digital Computer.

The RW-30 is an example of what can be accomplished through the application of digital techniques in conjunction with modern semiconductor components. It performs complete mathematical operations, including multiplications, at the rate of 4000 per second (as fast as large scientific computers). Yet it occupies only 4.19 cubic feet, weighs 203 pounds and uses 400 watts power. It is packaged in four separate units to facilitate installation in aircraft. The magnetic drum memory has a capacity of 2607 21-bit words.

The versatility inherent in digital techniques makes it possible for the RW-30 to handle such varied military aircraft problems as navigation, armament control and bombing, and combinations of these problems, without changes in the RW-30 itself.

The RW-30 also serves to illustrate the balanced integration of systems analysis and product engineering which is a principal objective at Ramo-Wooldridge. Similar programs are in progress on other airborne and electronic control systems, communication and navigation systems, and electronic instrumentation and test equipment. Engineers and scientists are invited to explore openings in these fields at Ramo-Wooldridge.

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"Well, I talked to a number of people and did as much letter writing and looking around as I could. The way I figured it, I wanted opportunity... a fair chance to put my capabilities to work and to be recognized for what I could do. Of course, I wanted to be well paid, too. It all seemed to add up to the aircraft industry... and to me it still does.

"In the space of just a few years I've worked on quite a few projects, important projects that some day may mean a great deal to this country. They sure meant a lot to me. And I wasn't standing still either. My salary and my responsibilities have increased with each promotion. That means lots of challenges, new and tough problems that we have to solve, but that's the way I like it. So, if you want some advice from this "old grad," choose the aircraft industry. It's the wisest choice, I'm in the business and I know."

Probably no other industry in America has grown so fast *and advanced so far* in a short time as has the aircraft industry. And yet there is no limit to how far man's inventiveness and imagination can push the boundaries. Radical new concepts that would have been unthought of just a few years ago are the drawing-board problems of today.

Truly aviation is still in the pioneering stage, and one of the leaders is Northrop Aircraft, which has been making successful contributions to our nation's defense for over 18 years. Projects such as the Snark SM-62, world's first intercontinental guided missile, have identified Northrop as a successful pioneer. And new aircraft such as the supersonic, twin-jet T-38 advanced trainer are maintaining this reputation.

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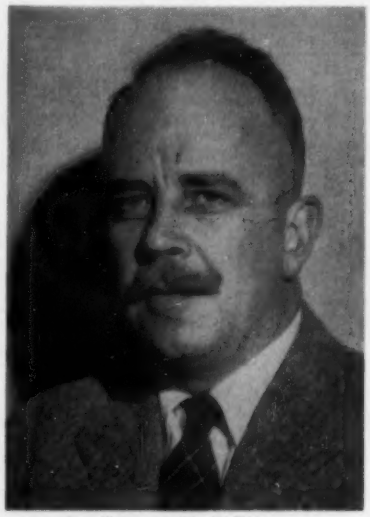


Roscoe H. Fuller

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S MESSAGE

Engineering and the Rational Approach

The role of the engineer in our modern civilization, as must be evident to any critical reader of current publications, is an ever-widening one. I speak here not of the proliferation of technical specialties, obvious enough in itself, but of the increasing realization that a disciplined, logical approach offers the best way to a solution of important problems in most fields of endeavor.

The qualitative argument, the subjective opinion, the emotional approach no doubt have their values, but it would be hard to think of a pursuit in which objectivity, rationality and logic do not offer much greater promise of success.

It is because of this that the value of the engineer becomes increasingly noticeable. It is here also, perhaps, that the wisdom of our College of Engineering in expanding the curriculum to include more work in background subjects begins to be obvious.

In manufacturing, design and research the position of the engineer has, of course, long been recognized. Because of the rationale which the engineer brings to his work, his duties have lapped over into sales, into management and into administration. Even in the various levels of government, long the almost-exclusive territory of lawyers, the qualifications of the trained engineering mind are coming increasingly to be sought.

Why are more and more engineers pre-empted to these non-technical duties? Certainly not because those who are, are not technically qualified. Certainly not because there are no others available and willing. The rational approach, quantitative thinking, engineering methodology, (terms which can be used almost interchangeably) seem to express the answer.

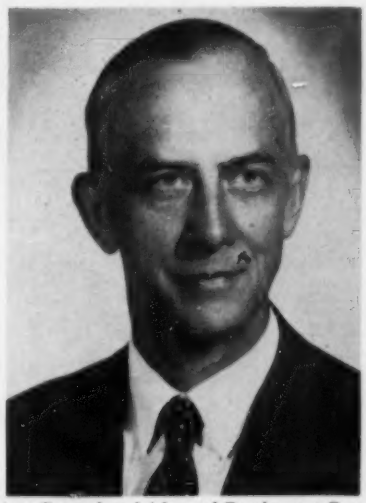
It is in these areas, many of us think, that will be found the answer to threats of technical superiority by hostile civilizations. The same breadth of training in fundamentals, both technical and administrative, that gives scope to our rationale; the ability to think through a problem objectively; the ability to assign quantitative relationships are the characteristic marks of the modern engineer.

To an increasing extent is this being recognized. Increasingly, engineering education is being broadened, rather than narrowed. So long as this trend continues we need have little fear of competition. We are fortunate, indeed, that Cornell is in the forefront of this movement.

So be grateful, undergraduates, for the correlative training you are getting; for the depth and breadth of the curriculum facing you. We of an earlier day have uncovered the need, and by experience learned to satisfy it in some measure. It is for you to carry on with the tools you are here learning to handle. The rational approach will guide you, and there is no limit to what you may accomplish. —Roscoe H. Fuller

ALUMNI ENGINEERS

Dr. Arne Wikstrom, CE '29, was appointed special technical assistant to the President of the Research and Advanced Development Division, Avco Manufacturing Corp., Lawrence, Mass. Dr. Wikstrom is a specialist in electronic and electromechanical systems and has had much experience in engineering, research, consulting and teaching. During World War Two, he helped develop sonar and radar systems for the Navy. Since then he has served as industrial consultant on new materials, senior consulting scientist on sonar and radar at Woods Hole Oceanographic Institution, Woods Hole, Mass., and more recently as project engineer on electronic airborne systems and shipborne navigational systems. Besides his experience in government and industry, Dr. Wikstrom has taught at Brown, University of California, University of Maryland and Cornell.



Avco Research and Advanced Development Corp.

Dr. Arne Wikstrom

Ellsworth C. Machin, Jr., BSCE '43, has been promoted to vice-president in charge of administration of E. C. Machin, Inc., general contractors of Allentown, Pa. He is chairman of the Allentown United Fund drive and of the engineer-architect committee of the Lehigh Valley chapter of professional engineers.

Dr. Robert J. Rubin, PhD '51, a physical chemist, has joined the Heat Division of the National Bureau of Standards. As a member of the Temperature Physics Section, he will plan and conduct theoretical research in solid state and chemical physics, with special emphasis on probems associated with chemical reactions, absorption, and energy exchange at high temperatures.

A native of New York City, Dr. Rubin was born on August 17, 1926. He was educated at Cornell University and received his Ph.D. degree in physical chemistry in 1951. After graduation Dr. Rubin worked at the Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Maryland, for four years. He then assumed an Assistant Professorship at the University of Illinois for two years, and this past summer served as a visiting research consultant for the General Motors Corporation.

His recent publications include papers on the propagation of deformations and shock waves in materials, on quantum statistical mechanics, and on application of statistical methods to polymer chains.

Dr. Rubin is a member of the American Physical Society, Sigma Xi, and Tau Beta Pi.

Alumni News, Nov. 15

Robert B. Lea

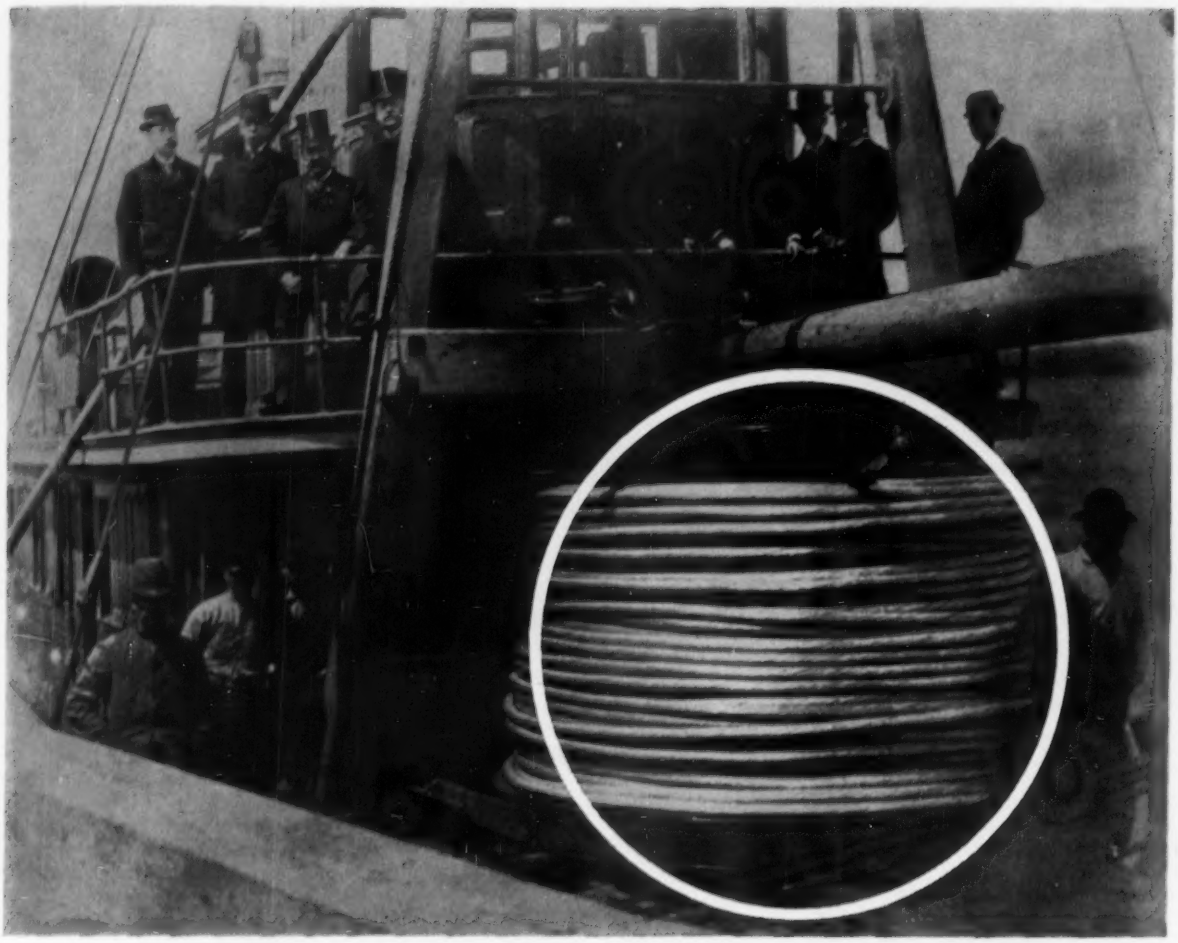
Daniel C. McCarthy, Jr., ME '48, has been named to the position of director of manufacturing planning for Chrysler Corp. He has been with Chrysler since 1956 as assistant to the director of the corporate manufacturing staff. Born in St. Paul, Minnesota, in 1924, he entered the automotive industry working in planning and control functions after his graduation from Cornell.

McCarthy is a member of the ASME and the Cornell Society of Engineers. He lives at 17158 Evergreen Street, Detroit, Michigan.

J. E. Coleman, EE '25, has been elected vice-president and general manager of Manufacturers Light & Heat Co. of Pittsburgh, Pa. He serves in the same capacity with two other companies which operate jointly as the Pittsburgh Group Companies of Columbia Gas System. His address is 16 Hazel Drive, Pittsburgh.

Ben-Ami Lipetz, BME '48, is assistant chief of the information management division of Battelle Memorial Institute, a non-profit research organization in Columbus, Ohio. His work deals with the establishment and administration of large-scale projects for the collection, analysis, storage, retrieval and dissemination of technical information. At present, his major projects involve information on titanium and the effects of the radiation of nuclear reactors on the properties of materials.

Robert B. Lea, ME '15, of 350 Lakeville Road, New Hyde Park, L. I., has retired from the Sperry Rand Corporation after forty-one years of service with the company. He is presently continuing his work with various engineering societies, including ASME, Society of Naval Architects and Marine Engineers, Society of Automotive Engineers and Cornell Society of Engineers (past president).



1880 *preferred then . . . and now*

THIS reproduction was made from an old photograph dated 1880, found in the Kerite archives at Seymour, Conn. It was taken as the steam tug "Western Union" completed the laying of an 18-conductor Kerite insulated submarine telegraph cable from New York, under the Hudson River, to Jersey City. It indicated that Kerite insulated cable was contributing to the furtherance of submarine telegraph circuits long before the turn of a century.

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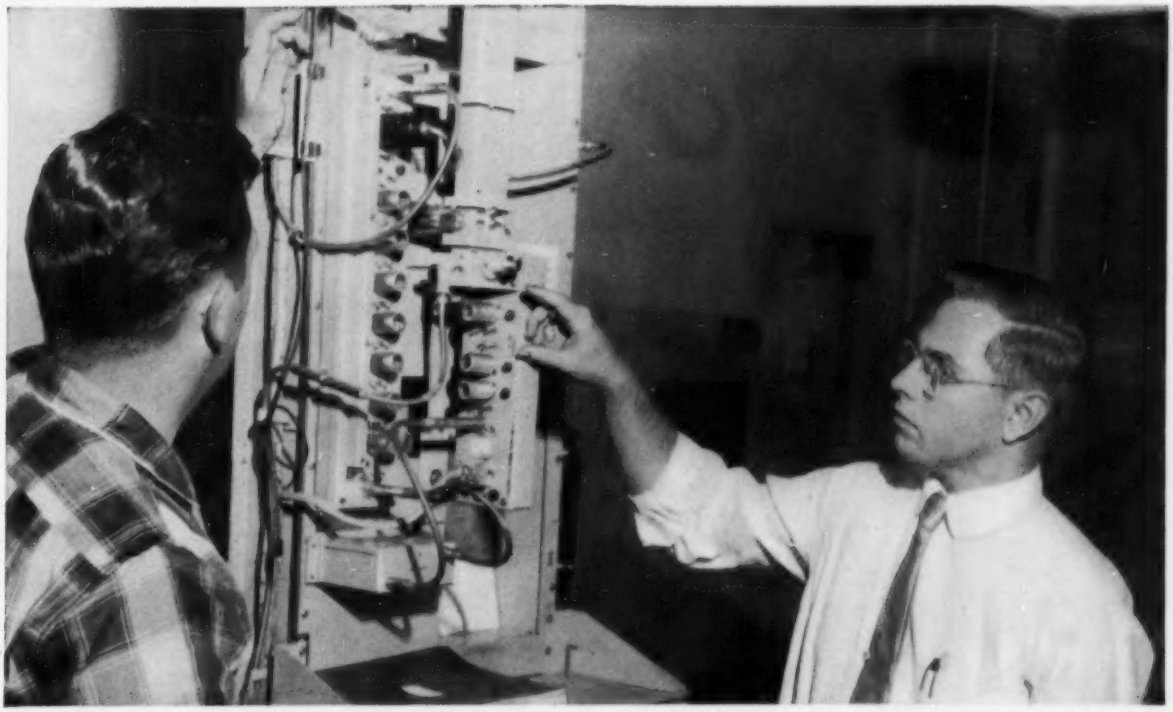

John Reiter (right) discusses the route of signals from the wave guide through the IF stages of a microwave receiver

"This was the kind of challenge I was looking for"

John A. Reiter, Jr., B.S. in Electronics, Arizona State College, '54, discusses the biggest project so far in his Bell System career

"One of the reasons I joined a Bell Telephone Company," John says, "was because the engineering would be more interesting and challenging. I knew I'd chosen well when I was assigned to assist in planning a microwave radio relay system between Phoenix and Flagstaff, Arizona. This was the kind of challenge I was looking for.

"It was to be a system requiring five intermediate relay stations, and I began by planning the tower locations on 'line of sight' paths after a study of topographical maps. Then I made field studies using altimeter measurements and conducted path-loss tests to determine how high each tower should be. This was the trickiest part of the job, because it called for detecting the presence of reflecting surfaces along the transmission route, and determining the measures necessary to avoid their effects.

"Not the least part of the job was estimating the cost of each of the five relay stations, taking into consideration tower height, access roads, and the need for special equipment such as de-icing heaters. All told, the system will cost more than $500,000. When construction is finished in December of this year, I'll be responsible for the technical considerations involved in connecting radio relay and telephone carrier equipment. Initially this system will handle 48 voice channels, but can be expanded to 540. In addition to long distance telephone service, it will also provide data transmission circuits.

"This assignment is an example of the challenges a technical man can find in the telephone company. You take the job from start to finish—from basic field studies to the final adjustments—with full responsibility. To technical men who want to get ahead, that's the ultimate in opportunity."

John Reiter is building his career with the Mountain States Telephone and Telegraph Company. Find out about career opportunities for *you*. Talk with the Bell interviewer when he visits your campus. And read the Bell Telephone booklet on file in your Placement Office, or write for a copy of "Challenge and Opportunity" to: College Employment Supervisor, American Telephone and Telegraph Company, 195 Broadway, New York 7, N. Y.

BELL TELEPHONE COMPANIES

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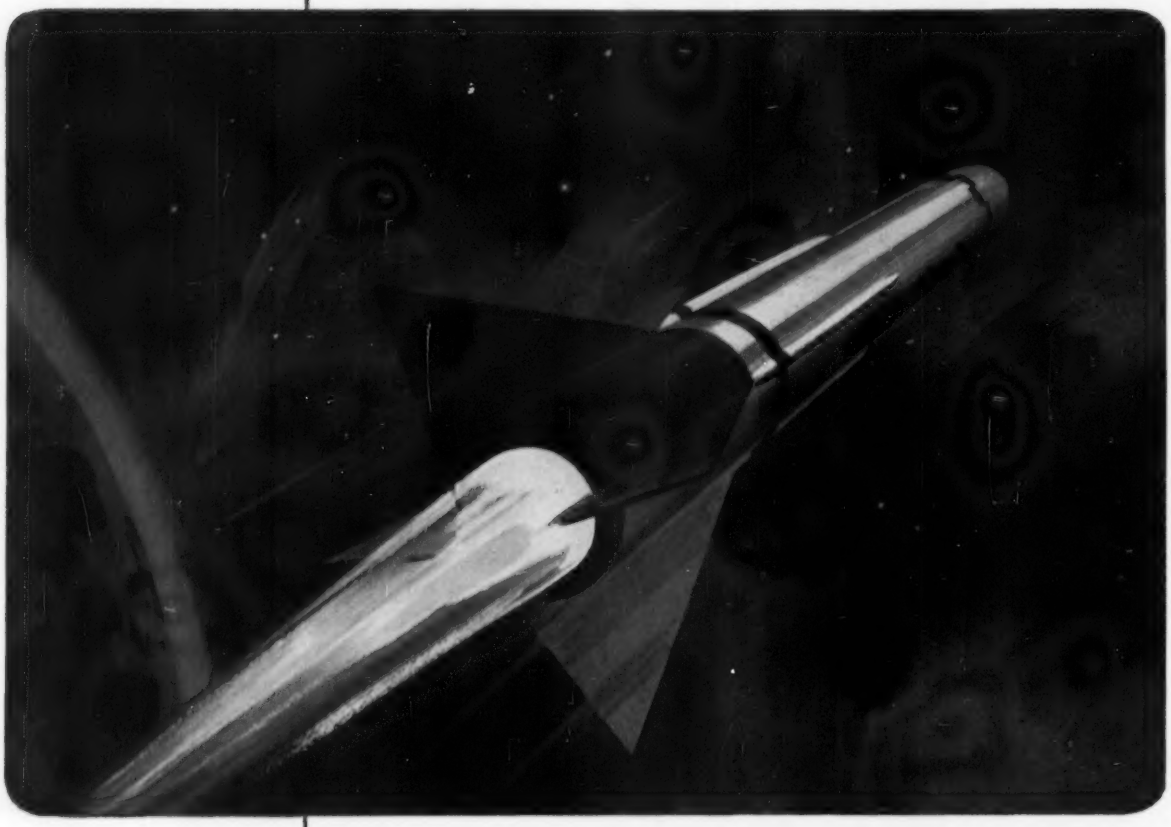

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 2000 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

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In the development of guided missile systems, the Jet Propulsion Laboratory maintains a complete and broad responsibility. From the earliest conception to production engineering—from research and development in electronics, guidance, aerodynamics, structures and propulsion, through field testing problems and actual troop use, full technical responsibility rests with JPL engineers and scientists.

The Laboratory is not only responsible for the missile system itself, including guidance, propulsion and airframe, but for all ground handling equipment necessary to insure a complete tactical weapons system.

One outstanding product of this type of systems responsibility is the "Corporal," a highly accurate surface-to-surface ballistic missile. This weapon, developed by JPL, and now in production elsewhere, can be found "on active service" wherever needed in the American defense pattern.

A prime attraction for scientists and engineers at JPL is the exceptional opportunity provided for original research afforded by close integration with vital and forward-looking programs. The Laboratory now has important positions open for qualified applicants for such interesting and challenging activities.

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TAU BETA PI ESSAY—

The Complete Man

by Richard O. Abbott, Arch '58

The world is changing rapidly day by day. New discoveries, concepts, and developments affect our lives in what seems to be an accelerating tempo. Man can no longer rely on past experiences with the same degree of reliability as once was the case. The entire concepts of laws and other factors affecting decision making have changed. How can man live a full, intelligent, and complete life in an era of extreme technology and specialization?

There is much clamoring today for return to the "Renaissance Man." The definition of this man concerns his fullness of capability in various fields of endeavor including art, engineering, science, and others. He was a well rounded individual, but by no means the average. He was a man with much talent and good fortune. The longing for a return to this type of man by some of today's intellectuals is, I believe, an illusion. The environment of today is not the environment of anything close to Renaissance Italy and cannot be.

What then can help men of today to live a more complete and meaningful life? The first is the psychological attitude of security in change and the second is awareness of the patterns and relationships of contemporary society. Education must strive toward these goals. The entire system of education seems to be fact oriented rather than pattern oriented. At some point in his education, today's student specializes without ever becoming aware of the important relationships in his society. A thorough grounding in relationships is mandatory for modern man to lead a meaningful life. Children must be taught the relationships of fact to probability, of quality to purpose, and of selection to awareness. These are all very general relationships and should form the background for future education. If these things were well established in lower education, higher education could be more profitably spent in developing intellectual curiosity, security in change, and specialized training.

People will say they know what they like, but in actuality they like what they know. It is only through an awareness of different fields of human activity, that one can hope to have taste and know quality in his everyday selections. This does not mean that everyone must be versed in every specific field of human endeavor. It does mean, however, that man needs the ability to be open-minded and must look at new developments as a child might, with enthusiasm, delight, and vitality.

We all have senses to help us perceive the world around us, but how well are these senses cultivated? Everyone knows the story of Helen Keller. This story should be of inspiration to all people. When the senses become tuned in on the world, life gains vitality.

To summarize, as basic for living in today's world one must think in terms of relationships, he must feel security in change, he must have an awareness curiosity, he must have specialized training, and finally, his senses must be cultivated.

Now in order for man to use these abilities in day to day living, he is faced with the problem of selection. Selection is the key word in the technical world of today. Information sources are so varied for us that we must select. News is presented in many different ways and media. One must realize how important selection is both at work and play, and with self and others.

A complete life is possible in modern life. Fullness in life is not given to man. He must make an active effort to achieve it. He must strive both for himself and his fellow man.

TECHNIBRIEFS

(Continued from Page 48)

NEW AREAS FOR MEASURING MAN'S INTELLECT DISCOVERED

Speeding new research in measuring man's intelligence is the first job given the electronic digital computer which was recently presented to the University of Southern California by the National Cash Register Company.

In addition to making computations in engineering and the physical sciences, the computer will play an important part in other fields of research. One example of this may lead to a comprehensive theory about the intellectual processes of man, with special emphasis on creativity.

The project is being conducted for the Office of Naval Research by Dr. J. Paul Guilford, SC professor of psychology, with Philip R. Merrifield as assistant director.

The old, standard IQ test, with its single score, comes a long way from being an adequate yardstick of adult intelligence, according to Dr. Guilford. His new system, based on about 45 established factors of intellect, provides a "many-sided" picture of intelligence; one of the implications of the system is that there may be as many as 75 intellectual factors in which individuals may differ.

The NCR electronic computer system, by reducing the time needed to analyze test scores, will make it possible to obtain the results, even from large groups of people, much more quickly.

As data from many tests are fed into the computer, intercorrelated results emerge immediately on punched paper tape. The tape in turn operates an automatic typewriter which rapidly prints the results in tabular form.

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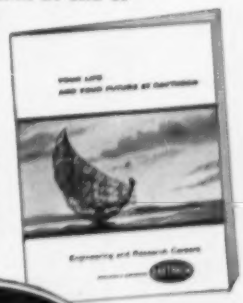

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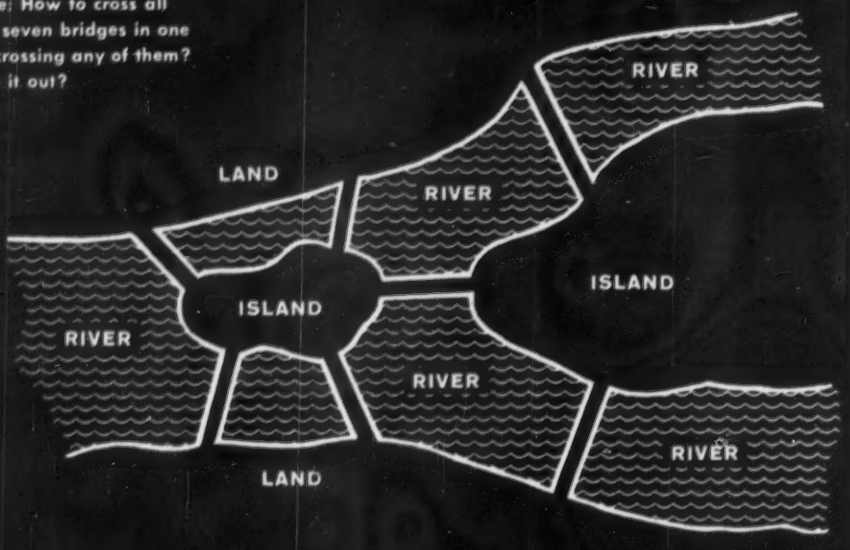
223 years ago, the good townspeople of Koenigsberg amused themselves with this puzzle: How to cross all of their town's seven bridges in one trip without recrossing any of them? Can you figure it out?



*"Solution" at bottom of page

Robert G. Hildenbrandt tells what it's like to be . . . and why he likes being . . . an Electronic Circuit Designer with IBM.

FIGURING OUT A CAREER?

Selecting a career can be puzzling, too. Sometimes, as with the seven bridges, the answers aren't always available. In engineering and research, it's just as important to discover that no solution may be possible as to find the solution. It is equally true in career selection that some companies can provide solutions . . . opportunities for growth . . . not always available in all companies. Here's how Bob Hildenbrandt *found* the solution to his career problem—at IBM: "Since joining IBM," Bob says, "I've seen some amazing developments in advanced circuitry. In my opinion, transistorized digital airborne computers represent one of the most progressive assignments in electronics today. As we enter the missile age, the technology of packaging and miniaturization will take on increasing importance. Transistorized computers offer an excellent chance for development work in computer circuits . . . high-frequency power supplies . . . magnetic amplifiers, regulators, storage devices. Challenge? It's tremendous—for we're working not only on present systems, but those of the future!"

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KILOWATTS ON TAP

(Continued from Page 33)

also operate as synchronous condensers, with the water exhausted from the wheel pit, and yet be instantly available to pick up load. The operating cost of hydro spinning reserve is much less than that for steam plants in which boilers must be fired and no load costs incurred.

4. The smaller size of a pump-turbine in comparison with a large steam unit makes possible small installations where steam would be uneconomical and permits a better fitting of capacity to the load curve. In addition the unit can be located in areas where steam would be impractical because of inadequate condensing water or other cause.

The amount of pumped-storage that a system may use is limited in relation to the total system load. Nevertheless, system loads are now so large in so many systems that, if pumped-storage does prove out, its use would lead to construction of much new hydro capacity. And a peculiar kind it might be—it may need less water than the alternative steam capacity and it always results in the use of more fuel.

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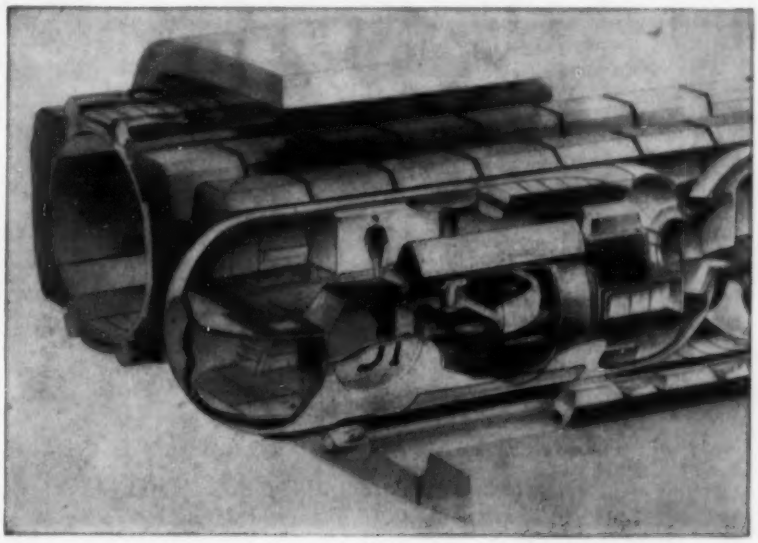
MARS outstanding design **SERIES**

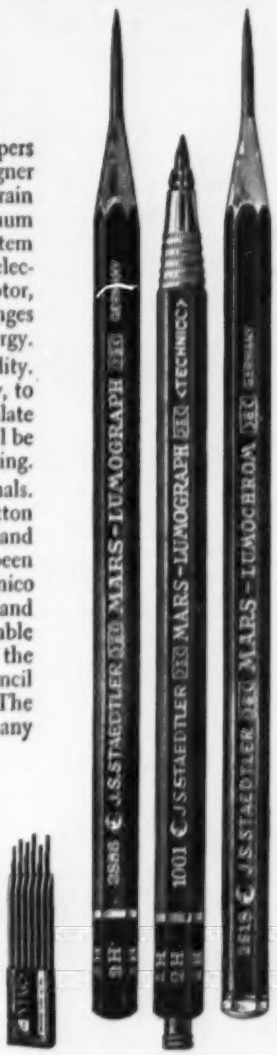


man and motion:

The wonders of the future are still little whispers in men's minds, or maybe — like Detroit Designer Norman James' magnetically suspended inter-city train — a drawing on a piece of paper. Traveling in a vacuum in an air-tight tube, it floats in space, held by a system of magnets built into cars and tunnel. Propelled electrically by "rolled-out" motor, train acts as rotor, tunnel roof as stator. Converter aboard train changes light projected through windows into electrical energy.

No one knows which ideas will flower into reality. But it will be important in the future, as it is now, to use the best of tools when pencil and paper translate a dream into a project. And then, as now, there will be no finer tool than Mars—sketch to working drawing.

Mars has long been the standard of professionals. To the famous line of Mars-Technico push-button holders and leads, Mars-Lumograph pencils, and Tradition-Aquarell painting pencils, have recently been added these new products: the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman's" Pencil Sharpener with the adjustable point-length feature; and — last but not least — the Mars-Lumochrom, the new colored *drafting* pencil which offers revolutionary drafting advantages. The fact that it blueprints perfectly is just one of its many important features.



The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom colored *drafting* pencil, 24 colors.

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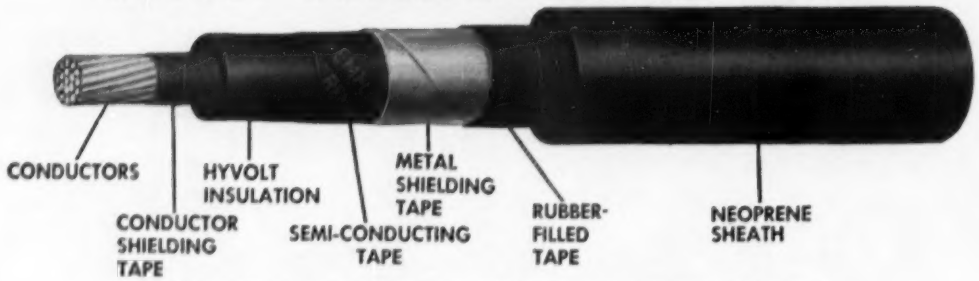

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COLLEGE NEWS

(Continued from Page 51)

CE SCHOOL'S CURRICULUM RECOGNIZED IN ARTICLE

Cornell's civil engineering curriculum has received special notice in an article, "Can Construction Be Taught in College," in the November 7th issue of "Engineering News-Record." Cornell's program is compared, subject by subject, with a program suggested by the Associated General Contractors of America for training construction engineers. The article concludes that "at Cornell, a five-year program provides the background for work in construction engineering. Educators believe this course is equal to or greater than that which is possible in a four-year college course, be it a special course in construction engineering or a construction option in a regular civil engineering course."

In addition, the Institution of Civil Engineers of England has decided that an engineer holding a B.C.E. from Cornell will be exempted from parts I and II of the Institution's entrance examination.

FOUR ME PROFESSORS PRESENT PAPERS BEFORE ASME MEETING

Four Cornell University faculty members have presented papers at the Annual Meeting of the American Society of Mechanical Engineers in New York City from December 1 to 6.

The four faculty members were Prof. Benjamin Gebhart, Prof. Howard N. McManus, Jr., both of Cornell's thermal engineering department; Prof. H. D. Conway of the engineering mechanics department, and Francis H. Raven of the machine design department.

Professor Gebhart's paper was "Unified Treatment for Thermal Radiation Transfer Processes." Professor McManus spoke on "An Experimental Investigation of Film Characteristics in Horizontal Annular Two-Plane Flow."

"Non-Axial Bending of Ring-Plates of Varying Thickness" was the title of Professor Conway's paper, and Raven spoke on "Velocity and Acceleration Analysis of Plane and Space Mechanisms by Means of Independent-Position Equations."

BOOK REVIEW

(Continued from Page 53)

fessor Mabie is presently doing research work on fatigue stresses of machine elements. He is building a machine to apply bending and torsion to non-circular shafts in order to investigate their properties. He is a member of ASME, ASEE, Tau Beta Pi and Phi Kappa Phi.

THE REVIEWER

Professor A. H. Church graduated with an ME from Cornell in 1928 and received an MS from New York University in 1934. He has worked at Westinghouse, Cooper Union, and De Laval Steam Turbine Company. He is now Professor of Mechanical Engineering and Chairman of the Mechanical Engineering Department at New York University. Currently he is on an Industrial Leave of Absence from N.Y.U. and is working at the General Engineering Laboratory of the General Electric Company. He has written books on "Centrifugal Pumps and Blowers", "Kinematics of Machines" and a book on "Mechanical Vibrations" that was released last December.

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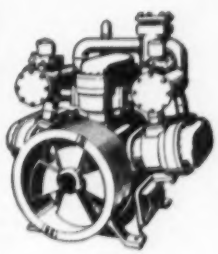

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What is an AGE engineer?

Wheeling, West Virginia — SUBSTATION ENGINEER Wilbur L. Kelvington outlines plans for service extensions to new customers.

New York City — NUCLEAR POWER ENGINEER Robert Hunter looks to the future in nuclear power research and development work.

Roanoke, Va.—ELECTRONICS ENGINEER Curtis Bondurant finds electronics fascinating and in widespread use on the AGE System.

Pikeville, Kentucky — DISTRICT SUPERVISING ENGINEER James R. Burdsal and Line Foreman discuss a power line maintenance problem.

Glen Lyn, Virginia — CHEMICAL ENGINEER David E. Kettlewell supervises the chemical laboratory at a major power station.

New York City—CIVIL ENGINEER Francis P. Keane helps design power plants and auxiliary facilities.

New York City—MECHANICAL ENGINEER John Tillinghast confers with manufacturer and colleagues on supercritical steam pressure unit.

Fort Wayne, Indiana — SUBSTATION ENGINEER Allen Wilson supervises installation of 345,000-volt oil circuit breaker.

Lima, Ohio — INDUSTRIAL POWER ENGINEER Cal Carlini tackles a difficult engineering problem posed by a major customer.

New York City—MECHANICAL ENGINEER Alfred J. Banks with a model of a new AGE generating unit.

Beverly, Ohio — TEST ENGINEER Norman Blair taking readings in the control room of a 430,000-kw generating plant.

Roanoke, Virginia — COMMERCIAL MANAGER John W. Vaughan directs the promotion and sale of electric power to customers.

Fort Wayne, Indiana—COMMUNICATIONS ENGINEER Wilho R. Roy has responsibilities in radio, microwave and carrier current communications.

Butler, Indiana — DISTRICT MANAGER William R. Nimmo supervises the restoration of service during a storm.

Columbus, Ohio — SYSTEM OPERATION ENGINEER William D. Omspach helps plan economical operation of world's largest private power system.

New York City — SYSTEM PLANNING ENGINEERS Conrad F. DeSieno and Anthony F. Gabrielle plan the AGE System of the future with a network analyzer.

Philo, Ohio — MECHANICAL ENGINEER Alan G. Lloyd helps supervise installation of world's first super-critical pressure generating unit.

Canton, Ohio—SYSTEM OPERATION ENGINEER Richard P. Blaes helps to coordinate load scheduling and the exchange of power with other electric utilities.

He's a man with a future. He may be any of the eighteen engineers pictured above who daily solve problems of energy conversion, power application, transmission and distribution. Or he may be one of our nearly 800 other engineers who work in eight states solving many stimulating and challenging problems faced by the AGE Electric Power System. Find out about career opportunities for YOU at AGE. Read our new 24-page brochure "Join the Company that *Makes* the News!" It's at your local placement office . . . or write for your own copy to any of the addresses listed below, attention: *Employee Relations Department.*

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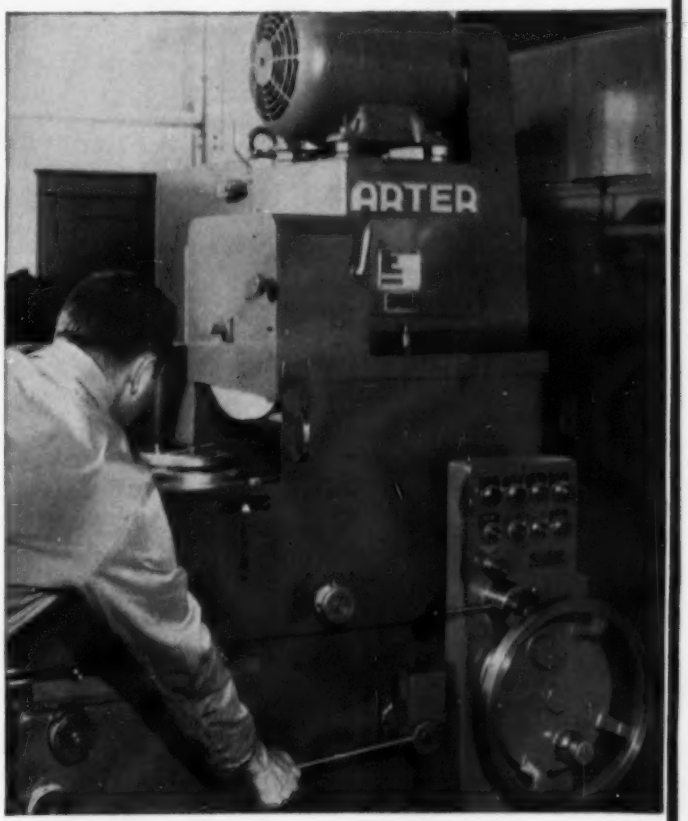
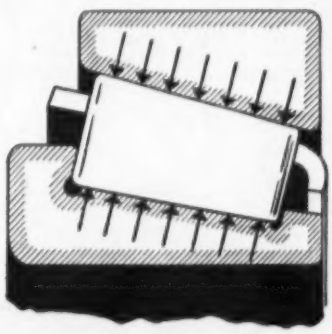
How to get higher spindle accuracy, cut costs too

The engineers who designed this new surface grinder had to be sure of the highest spindle accuracy in order to get the smooth spindle operation required for extreme precision work. To hold the work and wheel spindles rigid, maintain highest accuracy, the engineers specified Timken® "00" tapered roller bearings. Timken "00" bearings make possible the closest machining tolerances ever achieved. Run-out is held to 75 millionths of an inch. And they gave the manufacturer greater capacity in less space, cut manufacturing costs ⅓ over earlier spindles used.





How Timken bearings hold shafts rigid to maintain accuracy—The full line contact between Timken bearing rollers and races gives shafts rigid support over a wide area. Shaft deflection is minimized. And the tapered design of Timken bearings permits them to be set up with the most desirable amount of end play or preload that gives the best performance.

Want to learn more about job opportunities? Timken bearings help make better machines. Better machines enrich our lives, give us more spare time. It's what the Timken Company calls Better-ness. Want to help create Better-ness? If so—write for your free copy of: "BETTER-ness and your career at the Timken Company". The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL ◐ AND THRUST →◐← LOADS OR ANY COMBINATION →✳←

STRESS *and* STRAIN...

INVENTIONS FOR A BETTER TOMORROW:

No-calorie hair tonic for fatheads

Round mailbox for circular letters

Sundial with attached safety razor for eliminating five-o'clock shadow

Nail with thumb on top for clumsy workmen (can't miss the thumb with your hammer)

Magnetized lint (this lint picks up suits)

• • •

Engineer on telephone: "Doctor, come quick! My little boy just swallowed my slide rule."

Doctor: "Good Heavens man I'll be right over. What are you doing in the meantime?"

Engineer: "Using log tables."

• • •

Two salesmen were sitting in a local cafe when in walked a young fellow with a beautiful girl on his arm.

Interested, one of the salesmen sent this note to the young lady's escort: "I'm sure I studied with you at Harvard and my friend thinks he was a classmate of yours at Yale. May we come over to your table and straighten this out?"

The reply read: "Sorry, gents, but I studied at the National School of Taxidermy and I'm taking care of this pigeon myself!"

• • •

Naturally
A little nonsense now and then;
A little horseplay on the side,
Was relished by the wisest men,
Who really lived before they died.

• • •

A bored cat and an interested cat were watching a game of tennis.

"You seem very much interested in tennis," said the bored cat.

"It's not that," said the interested cat, "but my old man's in the racket."

• • •

He: "May I kiss you?"
She: (silence)
He: "May I please kiss you?"
She: (more silence)
He: "Say are you deaf?"
She: "No, are you paralyzed?"

For all you vodka fiends here is a new potion to add to your collection. Called the Sputnik, it contains two parts vodka and one part sour grapes.

• • •

Then there's the Ivy League cocktail—one sip and you get a belt in the back.

• • •

A shovel operator sitting at the bar was surprised to see a kangaroo enter the establishment and approach the bar. Taking his place next to the shovel operator, the kangaroo ordered an inverted boilermaker.

"How much?" the kangaroo asked the bartender as the drink was set before him.

"Two bucks," answered the bartender.

The kangaroo reached in his pouch, withdrew his wallet, and laid two bills on the bar. Then, downing the drink, the kangaroo turned to leave.

The shovel operator, watching bug-eyed, turned and said, "Pardon me, but I'm around here quite a bit, and I never saw any kangaroos in here before."

"I'm not surprised," answered the kangaroo, "when they charge two bucks a drink."

• • •

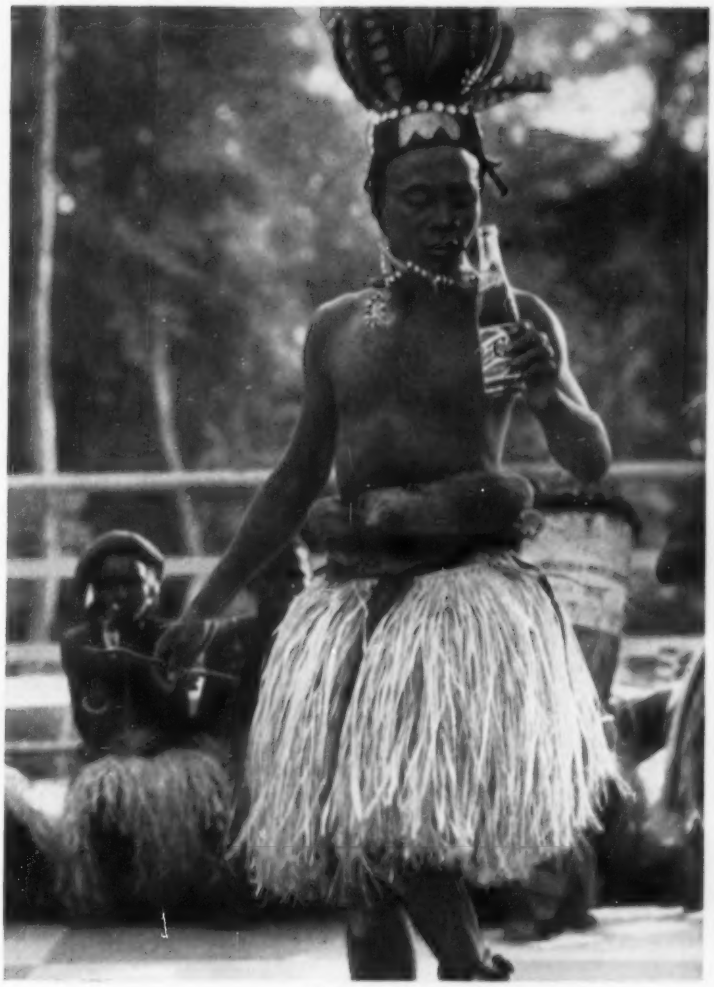
You must have heard about those ingenious Chem E's who developed a revolutionary vanishing cream deodorant. You vanish, and people wonder where the odor is coming from.

"I don't care how many final tests you have in one day, I can't sell it to you without a doctor's prescription!"

PHOTOGRAPHY AT WORK
No. 30 in a Kodak Series

Pepsi-Cola International Panorama, a magazine of places and people, reaches people around the world, builds recognition for Pepsi-Cola as a product associated with the better, happier side of life.

Photography speaks in every language



What better way to say people take naturally to "Pepsi" whether in Leopoldville or Lichtenstein?

This picture leaves no doubt that Netherlanders are neighborly.

To tell its story in 75 countries, Pepsi-Cola puts pictures to work to add meaning to the product's global billing as "the refreshment of friendship."

To build up an atmosphere of friendliness and understanding in markets around the world, Pepsi-Cola International publishes "Panorama"—and gives the brunt of the job to photography.

Photography knows no language barrier. It is clear to young and old alike—appeals to everyone. With photography, people are real; situations authentic, convincing. This is what makes photography such a powerful salesman.

Large businesses and small can use this powerful salesmanship—can also use photography to cut costs and save time in many other ways. It can help with problems of product design—can watch quality in production. It trains. It cuts office routine. You'll find that it can work for you, too.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production.

If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak
TRADE MARK

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, manufacturing and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical backgrounds.

Q. How about speed of advancement? Is G.E. a "young man's Company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • Qualities We Look For in Young Engineers • Personal Development • Salary.**

GENERAL ELECTRIC